The Blast Furnace and Steel Plant

Investigation of Stresses in Mill Housings

Stresses in Housings Caused by Spreading Forces on the Rolls. Harmful Influence of Sharp Corners — Factors Affecting Breakage—Effect of Shrinkage Stresses.

By J. D. KELLER.

Breakage of sheet mill housings causes considerable loss, not only because the housings themselves are expensive, but principally because housing breakage results in idleness of the hot mill stand. Housings of the form shown in outline in Fig. 1 were found to break quite frequently through the posts, a short distance above the housing feet; and the cracks always started from one or other of the sharp corners marked "G" and "H" in Fig. 1. Since this was a standard form of housing for 28 inch mills, it appeared very necessary to investigate stress distribution and to determine, if possible, the reasons for frequent breakage at these sections.

MR. KELLER'S report on his experimental investigation of stresses in sheet mill housings disputes the mill men's theory that the addition of material between lugs strengthens the housing, and shows, that on the contrary, this addition allows the lines of stress to be better established, consequently weakening the housing. The investigation reveals some interesting results which have also recently been confirmed in actual practice. Our readers are invited to discuss the article in the columns of The Blast Furnace and Steel Plant.

Purely theoretical investigation is of little value in cases like that of the housing, first, because of the very irregular form and numerous discontinuities of the latter, and second, because the width of the parts is great as compared to their length, (analogous to a short deep beam, or shore wide column). No complete theory, taking account of these conditions is available; and if the usual methods of calculating stresses in indeterminate systems are applied here, the results cannot be regarded as trustworthy. For these reasons the problem was investigated by experimental means. The results follow:

Stresses in the Housing.

Stresses along the inner edge of the housing, caused by a centrally applied load of 1,000,000 pounds, are shown by the curve, Fig. 6. The striking feature of the curve is the abrupt concentration or magnification of stress which occurs at the re-entrant angles, that is, at the sharp corners which extend into the material at the inner edge of the housing. Stresses at such corners are 8.5 times as great as those along the straight parts of the inner edge near these corners. Taking as a unit the average stress across the posts at section 1-1, Fig. 1 (since that is the stress which is usually figrued), the stress at corner "C," for instance, is 18. units. Stress increases abruptly as a sharp corner is approached, and the effect of the latter extends only a short distance from it.

At sharp corners extending outward the stress was found to be zero.

Except at the corners, stress is quite uniform along the vertical part of the inner edge of post, its value being 1.90 units. At and near the upper and lower rounded corners, stress increases about 30 per cent, to 2.50 units.

Stress across the post at section 1-1 (Fig. 1) decreases from 2.10 units at the inner edge to practically nothing (.18 unit) at the outer edge.

Across the upper surface of the top section, (through the screw box hole, or the "eye"), the stress is not uniform, but varies, as shown in Fig. 2, from .65 unit at the face of the housing to 4.0 units at the edge of the screw box hole. No other important stresses exist at the outer edge of the housing.

Stress concentration at sharp corners of the vert-

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ical slots is not so great as that at corners "C", "D", etc., due to the restraining action of the material at the bottom of the slot. Still, the stresses at these corners are quite large.

When a sheet mill housing is subjected to shock by the impact of the top roll, brass and rider upon the

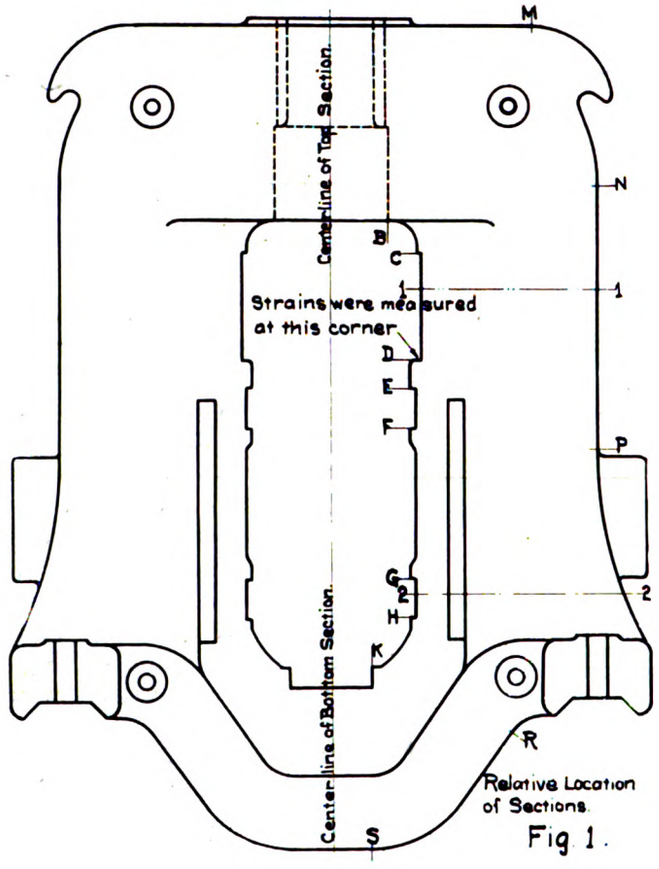

Fig. 1.—Relative location of sections.

lower end of the top screw, resisting forces develop which act through the housing feet. Principal features of stress distribution produced by these forces are, an increase of stress at the inner edge from almost nothing at section H to 2.2 units at section 1-1, and a stress of about 19 units at corner "C"; also a local stress of 3.5 units just above the housing feet, caused by the local application of the load.

Experimental Methods.

Some of the readers may be interested to know how these results were obtained. The experimental method which was used depends upon the inter-relation between stress and strain. By measuring the latter, the corresponding stress can be found if the stress-strain curve of the material is known. (By "strain" is meant the ratio of deformation to original length). Since deformation, and hence strain, is measured as the small difference between two large quantities, it is necessary, in order to obtain reasonably accurate values for this difference, to use a material which can undergo large deformations while retaining its elasticity.

A rubber model was therefore obtained, of the form of a sheet mill housing, but to a reduced scale, (1/12 full size); fine black lines were ruled on its side and top, at small intervals; the model was photographed, first in the unstressed condition, then under stress; the distances between the lines at certain points were measured on each plate, by means of optical micrometric apparatus; the differences in length and the strains were calculated, and the stresses were then found from the stress-strain curve of the rubber. To find stresses at the edges it was only necessary to measure deformations along the latter, since at the edges all lateral stresses vanish, except where an external force is applied. At such points, and also in finding stresses at other points of the surface, not at the edge, it was necessary to measure the deformations along two lines perpendicular to each other through each point, and to find the change of angle between these lines. Stresses between the

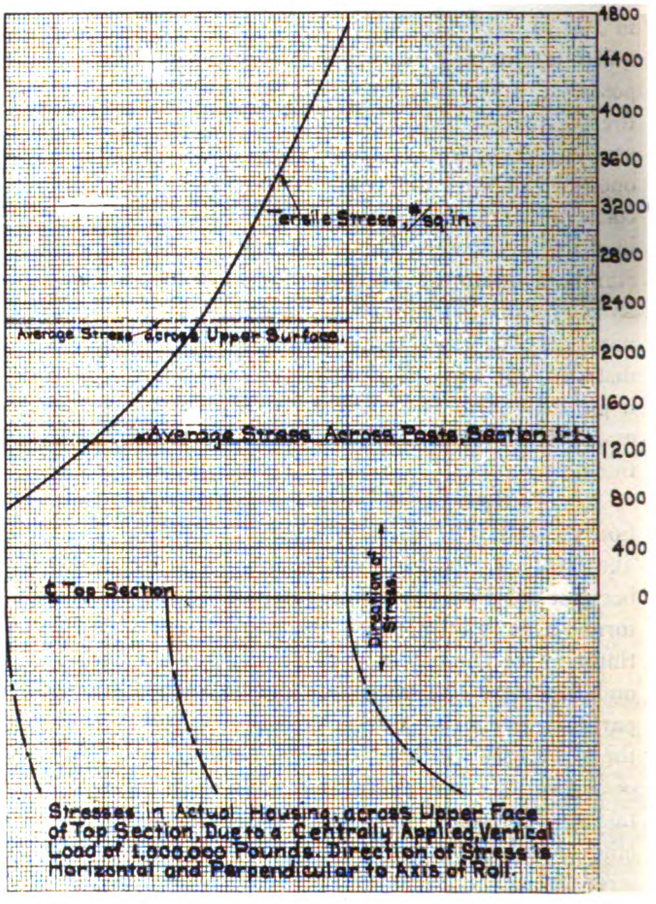

Fig. 2.—Stress across upper surface.

edges are always less than the maximum stress at the edge; and at only a few points are they sufficiently important to justify measuring them. Of course the rubber model method is not original. It was used as long ago as 1878 by Winkler, and has been used by other experimenters since that time.

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Fig. 3 shows the model when unstressed, and Fig. 4 shows its appearance under stress. Fig. 5 shows the arrangement used for stressing the model by means of weights, when making photographs of the side of the model. The load was also applied through the

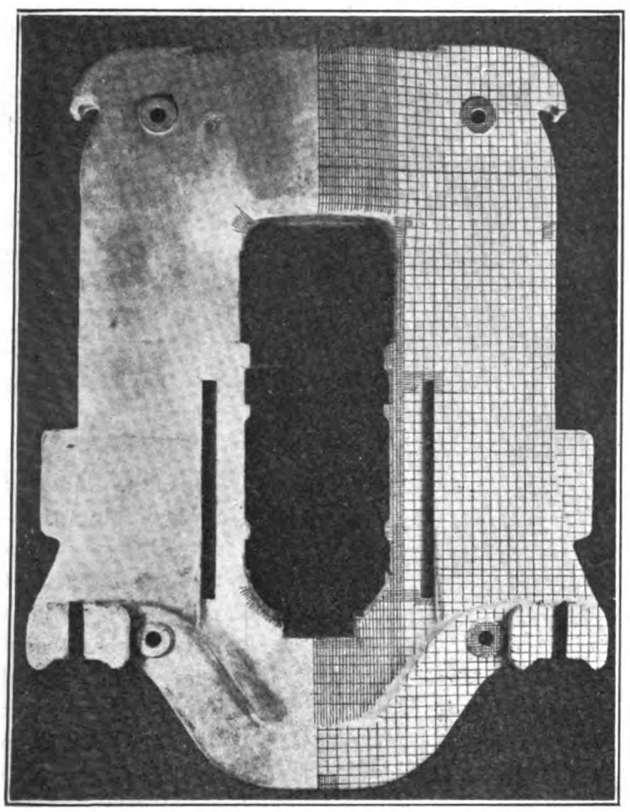

Fig. 3.—Model without stress.

housing feet, instead of at the centerline as shown in Fig. 5 by four bolts supporting a plate from which a rod depended, having at its lower end another plate on which the weights were placed. The appearance of the top of the model under stress is shown in Fig. 7.

The smaller lengths on the photographic plates were measured with a micrometer microscope, which was of the usual type having a fine double hair line moved by a fine-pitch screw. In this instrument the objective lens is focused so as to form an image of the object to be measured in the plane of the movable lines, and both image and lines are considerably magnified by the eye-piece. For measuring the larger spaces a special micrometric slide apparatus was constructed, which consisted of a thin glass slide having a very fine line ruled on its lower surface near the end, and perpendicular to its line of motion; and having the other end bent vertically upward so as to rest against and be moved by the end of a micrometer head, which was fixed in a frame resting on the plate. The gelatine coating of the photographic plate was placed uppermost, and it was illuminated from below. Since the line on the lower surface of the glass slide was in contact with the gelatine coating of the plate, errors due to parallax were not present. When using this apparatus the optical micrometer was used just as a plain microscope, except that one of its lines served as a reference line.

The length measured was, of course, the difference between the micrometer readings obtained when the line on the slide was made to coincide in turn with each of the lines on the photograph, bounding the space to be measured.

Elastic Characteristics of Rubber.

Tensile and compressive tests were made on specimens of the material of which the rubber housing model was made, in order to find the stress-strain curves of the material. Fig. 8 shows the curve for tension, as far as the test was carried. (This is not the complete curve to the breaking point—that would show a much greater extension.)

Stresses in the Rubber Model.

The variation of deformation and stress along the

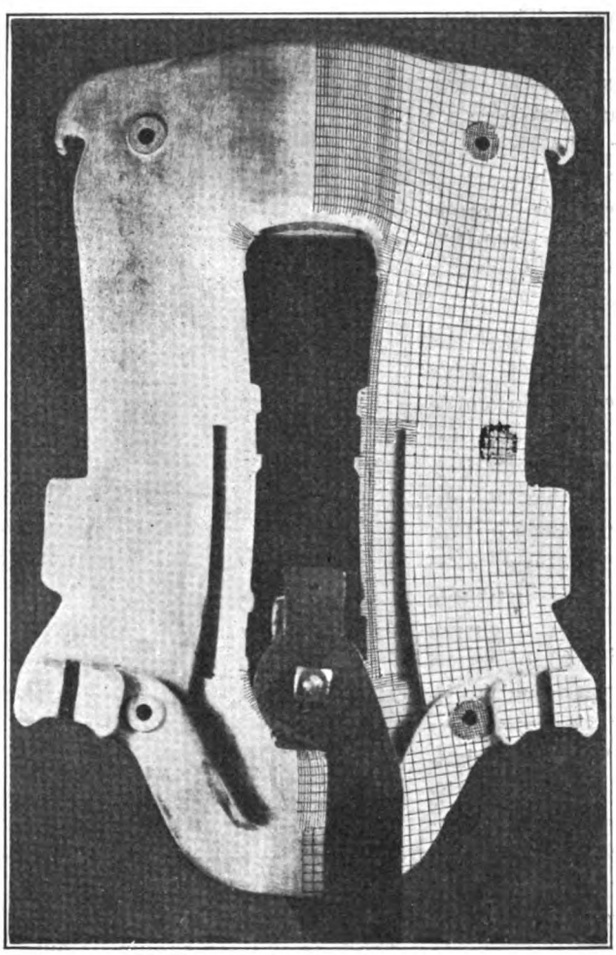

Fig. 4.—Model under stress.

inner edge of the model is shown in Fig. 10. The extreme deformation which occures at the sharp corners can be observed in the photograph, Fig. 9.

Only at corner "D", Fig. 1, could lines be obtained which were suitable for measuring deformations at

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the corner. The curves have been drawn to show stresses at the other corners having the same ratio to the stresses in the straight parts of the edge near those corners, as the stress at corner "D" is to the stress in the straight part of the edge near "D." It is regretted that suitable lines could not be obtained at the other corners, in order to confirm the results of the measurements at corner "D"; but, as will be shown below, good reasons exist for believing them to be applicable to any of the corners. An exception is to be noted, however, with respect to corner "K." Stress correspondng to deformation actually measured at that corner has been shown. The measured space here was much longer than that at corner "T," however, hence the actual stress at corner "K" is probably much higher than the curve shows.

In view of the fact that the stress-strain curve of cast iron is not extremely dissimilar to that of rubber, (shown in Fig. 8), it was considered justifiable to plot curves (Fig. 6) of stress in the actual housing, showing stress distribution similar to that in the rubber model: except at the sharp corners, where the stress were figured by a different method, as will be shown below.

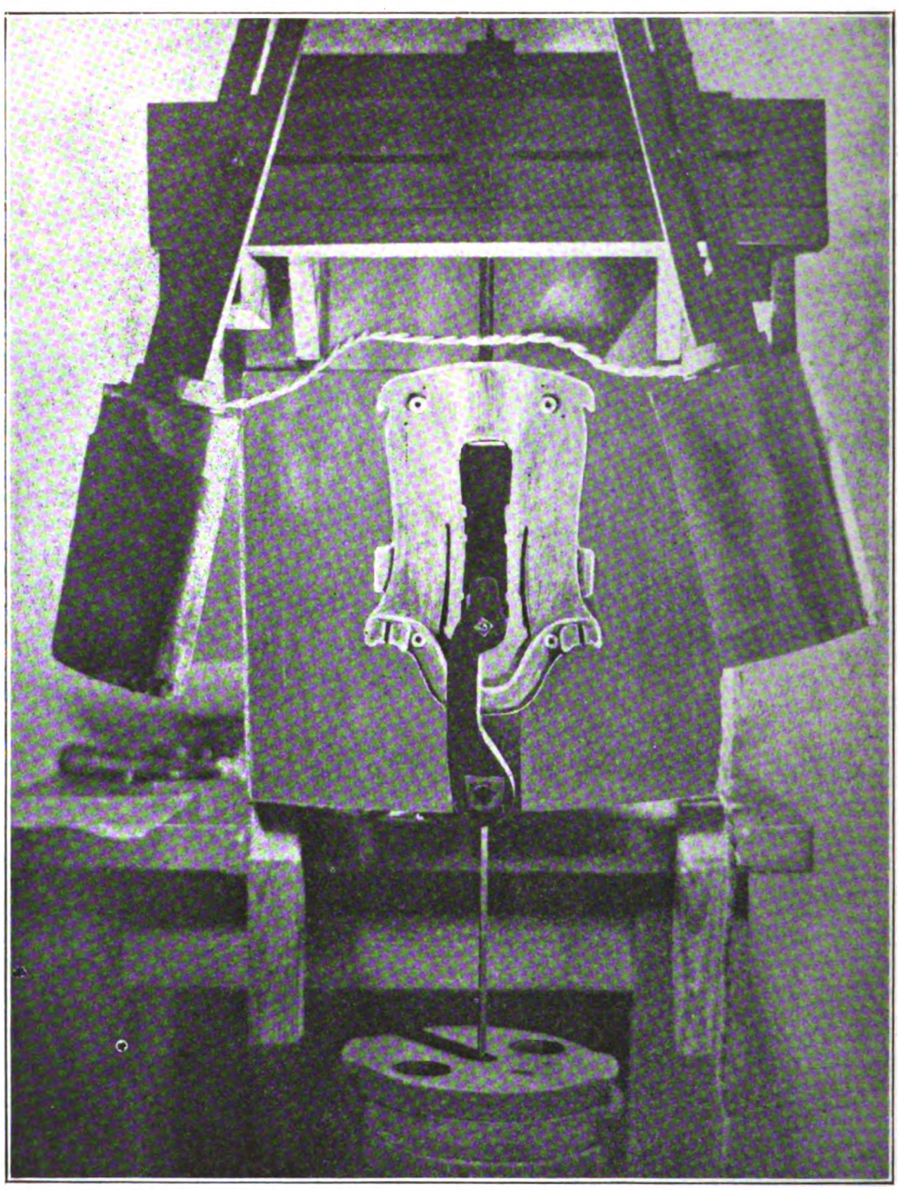

Fig. 5.—Arrangement for loading and illuminating model.

Forces Acting on Sheet Mill Housings.

These include 1:—Vertical spreading forces. 2:—Horizontal forces exerted by the top roll. 3:—Inertia force of the stock which is being rolled. 4:—Incidental forces which cannot be calculated, such as forces transmitted by the spindle, and end thrust caused by diagonal roll breakage.

The vertical force tending to spread the rolls apart is much the greatest, and in fact it is the only important force acting on the housing. Its magnitude can be calculated from the formula for spreading forces on rolls, derived from experimental data by Professor W. Trinks in "The Blast Furnace and Steel Plant," May and June, 1915. In 28 inch sheet mills the force on each housing may reach, but probably does not exceed, 1,000,000 pounds. Due to friction of the roll necks, the line of action of this force does not pass directly through the center line of the housing. The effect of its eccentricity, however, is negligible.

The writer does not know of any complete theoretical investigation of direct stresses in bodies having sharp corners. For a special case, however, that of a curved beam with infinitesimally small radius of curvature, (that is, a sharp corner), it is known that stress at the corner would theoretically be infinite. By analogy with the result of Saint-Venant's study of torsional stresses in bodies having sharp re-entrant corners, in which he found the stress at these corners to be infinite, the same result might be expected at any sharp re-entrant corner in a body subjected to bending. Of course we know that no such stress actually occures. The reasons are, that a corner is never absolutely sharp, but has always some small radius; that the stress-strain curve of the material deviates widely from the straight line of Hooke's law; and that the deformation at the corner is not infinitely small; all of which must be assumed, in

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any theoretical investigation of the problem, to be true. But we should certainly expect a very high, though not an infinite stress at such corners.

Confidence in the correctness of results of the present experimental investigation was greately strengthened by comparison with the work of Preuss, (Zeits. d. V.deutscher Ingenieure, Aug. 24, 1912). By means of an extremely delicate deflectometer, Preuss measured the deformaton at a sharp corner extending into a bar of wrought iron which was subjected to tension and bending; and found that the elongation was 9.1 times as great as that corresponding to the bending stress at the corner as calculated by the elementary theory of bending.

Since the measured space must extend some distance on each side of the corner, the measured elongation and its corresponding stress are average values for the space, and hence must be less than those existing just at the corner. For this reason, and also because the relative elongation found by Preuss for wrought iron agress quite well with that measured at corner "D" in the rubber model, the stresses for the sharp re-enterant corners of the actual housing have been calculated on the assumption that the proportion of elongation at the corner to that in the straight part of the edge near it, is the same for the cast iron housing as for the rubber model; rather than on the assumption that the proportion of stresses is the same. Neither is quite correct, but the former method gives a somewhat higher stress at the corners than the latter, and this would tend to compensate for the error caused by the finite length of the space measured at the corner.

Stresses at corners "E," "F" and "G" are probably less than those calculated on this basis and shown in Fig. 6. for the reason that, as the length of the lugs supporting the side brasses is small and they project only a small distance outward, the lines of stress do not have an opportunity to become so well established in the lugs as in parts near "C" or "H," before encountering the sharp corners where they must concentrate. (That only small stresses exist in the lugs is shown by the measurements.) This is confirmed by actual mill experience. In one design the space between the lugs was filled in, so as to form one continuous extension from section F to G. Instead of

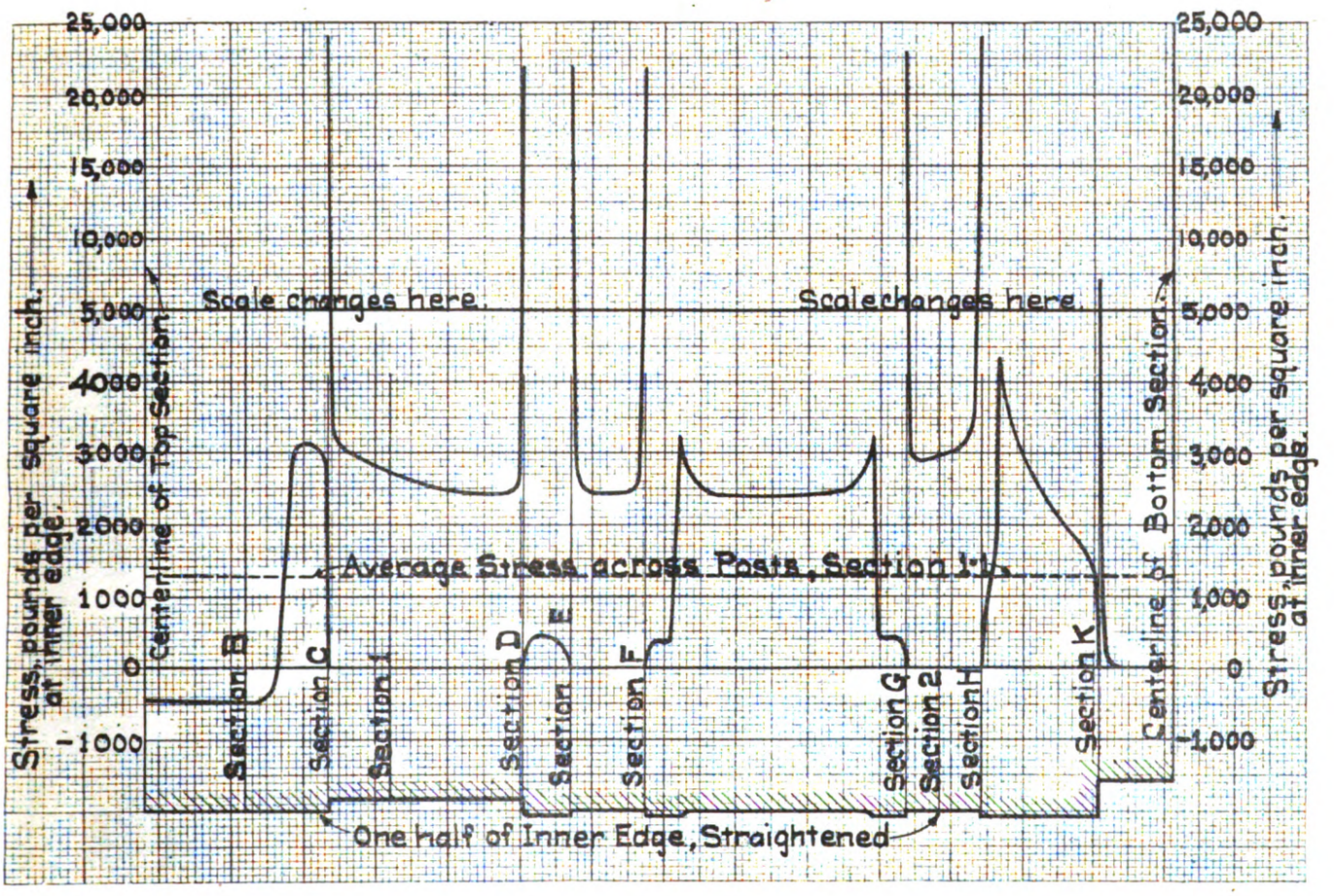

Fig. 6—Stresses at inner edge of housing, showing stress in full size housing, due to a centrally-applied, vertical load of 1,000,000 pounds.

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increasing the strength of the housing as was expected, this change made it considerably weaker, because lines of stress became better established in the filled-in part, and their concentration at corners "F" and "G" produced more severe stresses than before.

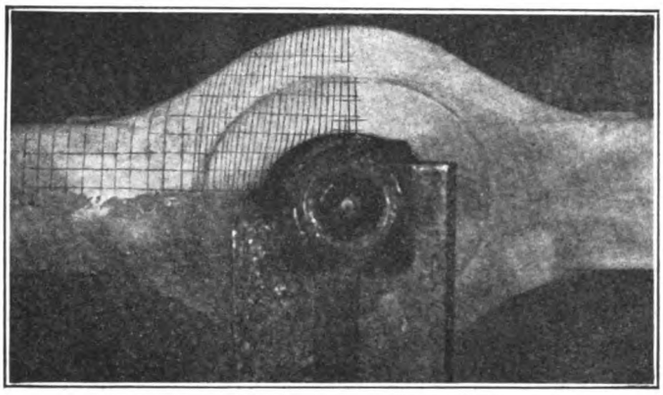

Fig. 7.—Top surface of model under stress.

Finally, records of housing breakages show conclusively that in all cases except those of breakage through the top section, the crack starts at some one of the sharp corners.

The Effect of Shock.

In most sheet mills the top roll is not balanced, but rests on the lower roll when no steel is passing through the mill. When the steel enters the rolls, the top roll is thrown up by it with considerable velocity, carrying the top brass and rider with it, and strikes against the lower end of the top screw with violent shock. This shock is transmitted to the housing, passes through the housing feet and is transmitted by the holding-down bolts to the mill bed plate. The

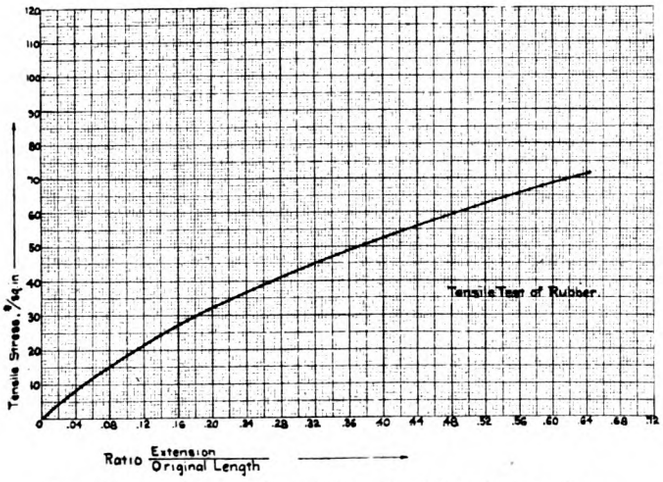

Fig. 8.—Stress—strain curve of rubber in tension.

forces are not, in this case, self-contained or equalized within the housing, as they are later, after the shock has been absorbed. A rough calculation for most severe conditions shows that, deducting the energy absorbed in overcoming inertia of the housing, the maximum force exerted during shock would be 180,000 pounds. The maximum stress would be 4,300 pounds per sq. in. at corner "C." This stress is not added to that caused by spreading force, since it does not exist at the same time.

Discussion of Housing Breakage.

A purely static load of considerably more than 1,000,000 pounds applied to the housing would not be sufficient to break it. The highly stressed material at the sharp corners would quickly pass to the drooping part of the stress-strain curve, and would stretch with little increase of stress; consequently as stress was added it would be transferred to the adjacent layers of the material. Stresses would thus tend to equalize, and consequently the stress distribution at breakage would be entirely different from that existing with smaller loads. This means that stress variation at breakage would not be the same as that shown in Fig. 6 and that the sharp corners would not be such a source of weakness under static load as this curve shows. Under combined shock and repetitions of heavy loads, however, these corners are just as weak as the curve indicates.

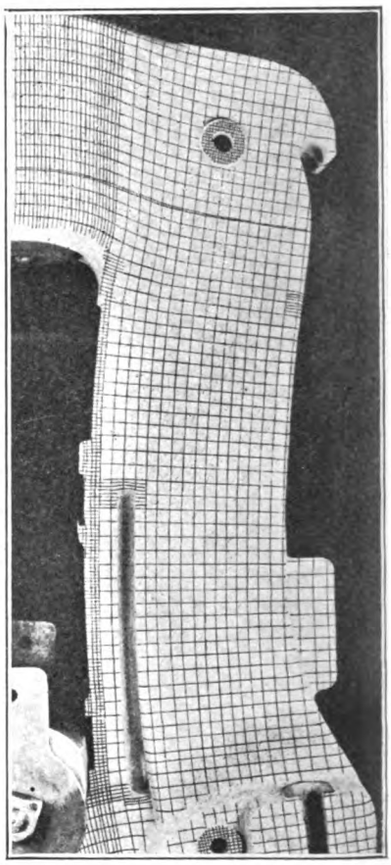

Fig. 9.—Post of housing model under stress.

That static load alone is not responsible for housing breakage is shown by the fact that housings seldom break at once entirely across the post. What actually occurs is as follows. After a sufficient number of shocks and repetitions of load have taken place, the microscopic flaws or slips along the cleavage planes of the crystals join and form a visible crack at the sharp corner, whence it gradually extends across the post. An exceptionally large force caused by cold steel may, after the crack has started, caused sudden complete failure. Across the top section stress is not closely localized, hence if breakage takes place at this section, it occurs suddenly.

Failure of housings is due, first ,to the presence

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of internal casting stresses, the magnitude of which is unknown, but which vary from place to place in the casting; second, to the repetition of a static load which produces, at the sharp corners, stresses approaching the ultimate strength of the housing material; third, to the sudden application of load with violent shock. Probably no one of these factors would be sufficient in itself to cause breakage; that results only from the combination of all three. As regards static load or repeated loads due to the spreading force on the rolls, there is no reason why the housing should break at corner "H" rather than at corner "C." Under shock conditions, a much greater stress would exist at "C" than at "H." To explain the observed fact that breakage of the housings occurs most often at corners "G" and "H," there remains only the first factor, namely, internal casting stresses. Evidently much greater shrinkage stresses must exist at "G" and "H" than at other sections. This appears probable when we consider the large mass of metal near these sections, which remains molten after the rest of the iron has solidified. That shrinkage stresses may be very severe is shown by the occasional breakage of castings when no external force is acting on them. In one case known to the writer, a cast steel housing broke (while being annealed) through section "H" of one post and section "C" of the other.

The writer wishes to thank the Carnegie Institute of Technology for the use of apparatus. In particular does he wish to acknowledge the encouragement and unfailing interest in the experimental work, shown by Professor W. Trinks, head of the department of mechanical engineering at Carnegie Institute of Technology. The apparatus, methods, results and calculations pertaining to the experimental investigation are fully described in a complete report which is on file at that institution, and which can be examined at any time by those interested.

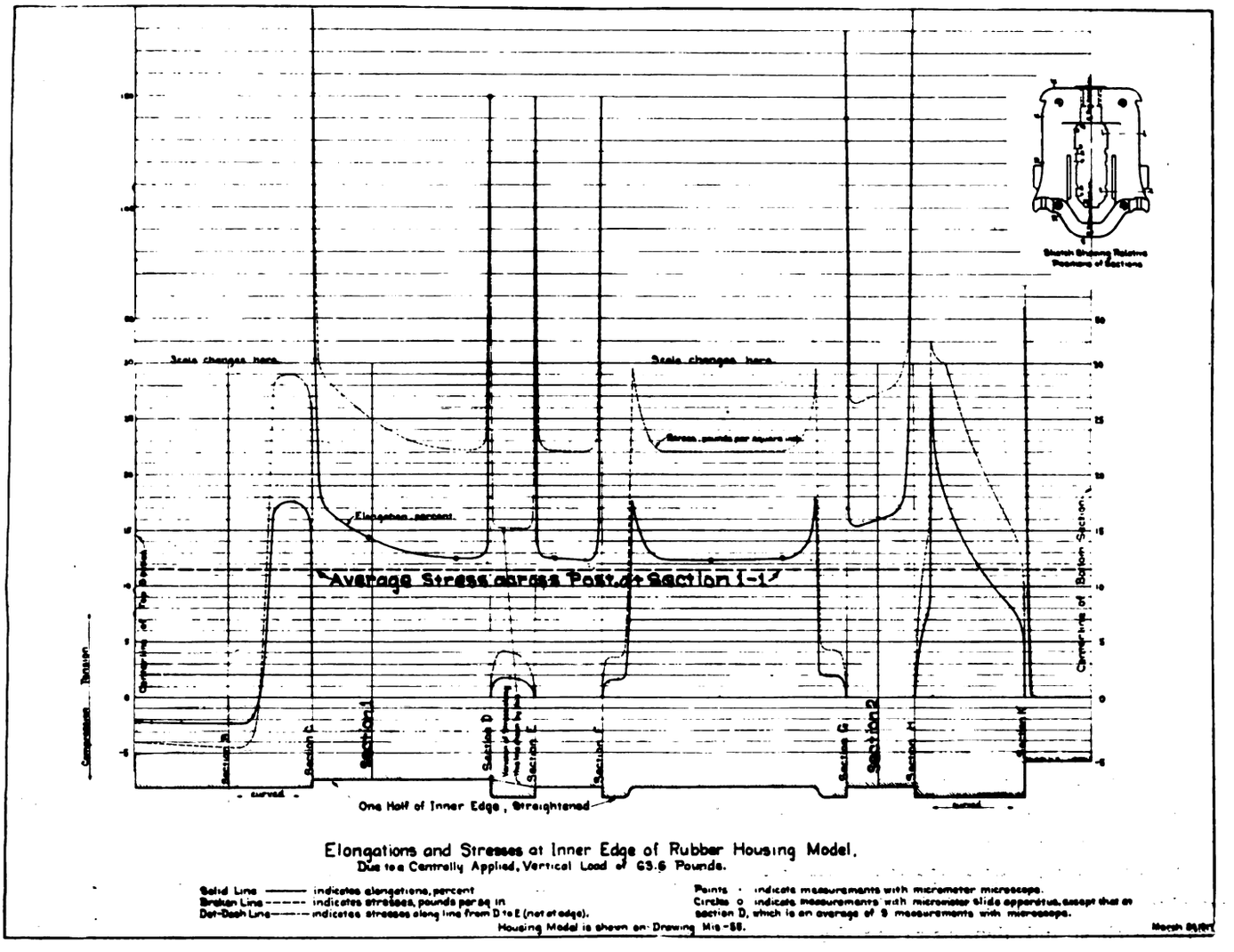

Fig. 10.—Stresses at inner edge of model.

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Cotton Rope for Power Transmission

Comparison of Cotton and Manila Rope—Consideration of Centrifugal Force, Sheave Diameter--Effect of Over Roping—Example of Steel Mill Installation—English and American Practice.

By J. MELVILLE ALLISON.*

In combating the question of cotton or manila for transmission ropes, one must not lay too much stress upon initial cost, for although cotton is dearer than manila, its superior resilience, grip and groove impact add so greatly to driving force that up to one-third more horsepower may be transmitted.

Tensile Strains:—The tensile strain of a driving rope does not enter largely into the problem, else manila would undoubtedly hold the field, but its fibers are of so harsh and wiry a nature, that they do not take kindly to the successive twisting and bending operations, nor do they cling to the sheaves with the tenacity of the softer materal. Having little natural resilience. the strands scrub one upon the other, setting up internal abrasion, which not only proves an inconstant quantity, but also invariably leads to repeated tightenings.

Three vs. Four (or more) Strand Ropes:—Rope of three, four or even seven strands is sometimes em-

Fig. 1—Sections of three and four-strand ropes.

ployed, but since the contest lies mainly between the three and four strand, it will suffice to demonstrate the advantage held by the three strand over the four or any other construction.

Examining the section of a three strand rope, Fig. 1, we obtain an equilateral triangle by connecting the centers of each strand, demonstrating the triangulation of the strains, a principle adapted by the engineers in erecting angular constructions, such as bridges, etc. In a rope of this construction we have a trinity of elastic spirals, so supple that they will bend to and fro with out disturbing their formation. With the four strand rope adopting the same method of connecting the strand centers, we obtain a square and an illustration of the parallelgram of forces from the four centers. Again, the four strand rope cannot be constructed without a supporting core, and since it is indispensible to its construction, its collapse must mean the dislocation of the whole structure, and as the core represents only about one-fourth of the area, it may be reasonably assumed that the superior force exerted by the alternate contraction and extension of the spiral as the rope passes over the sheaves, must tend toward the breaking up of this core, the period of endurance being limited by its elasticity and the tension at which it is laid. This is what actually takes place.

Spiral Elongation:—This will probably be the more readily grasped by referring to Fig. 2 which shows a three and four strand rope in parallel, with the turns of one strand indicated by the figured lines. Thus the turns of the three strand gradually gain upon the four in the proportion of one in five or in other words, six turns of the three strand occupy the space of five turns on the four strand, i. e., in ropes of the same thickness. The strand spiral of a seven strand rope is nearer the

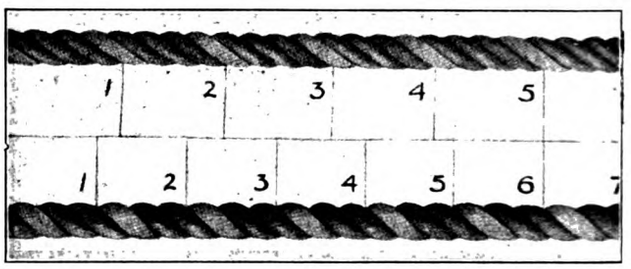

Fig. 2.—Relative elongation of three and four-strand ropes.

straight line, being almost double the length of a three strand rope. It will, therefore, be acceptable that the medium engaging the greatest number of turns should prove to be the most resilient and more capable of disposing of the shocks and stresses set up in rolling mill work than any other. Again, as affecting the bending capacity of the rope, another important difference is observable—only two strands appear between every turn of a three strand, while three occupy the spaces between every turn of a four strand.

Fixed or Revolving Ropes:—It has been a matter of education in England to get the engineer to agree as to whether the fixed-wedged or revolving rope is the better driving medium. The wedged rope with its angular formation gains in groove contact over the revolving rope and contact means power. Further, the wedged rope cannot have the tendency to slip which the revolving rope would have, and also the life of the revolving rope is considerably reduced. The cause of ropes revolving is difficult to ascertain, but it is computed that

* Abstract of paper published in the proceedings the Engineers Society of Western Pennsylvania, Page 271, June 1917.

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the life of a rope is reduced by at least one-third when it revolves.

Ropes which are underworked will very often tend to revolve, a golden rule in rope transmission being that ropes like work to do.

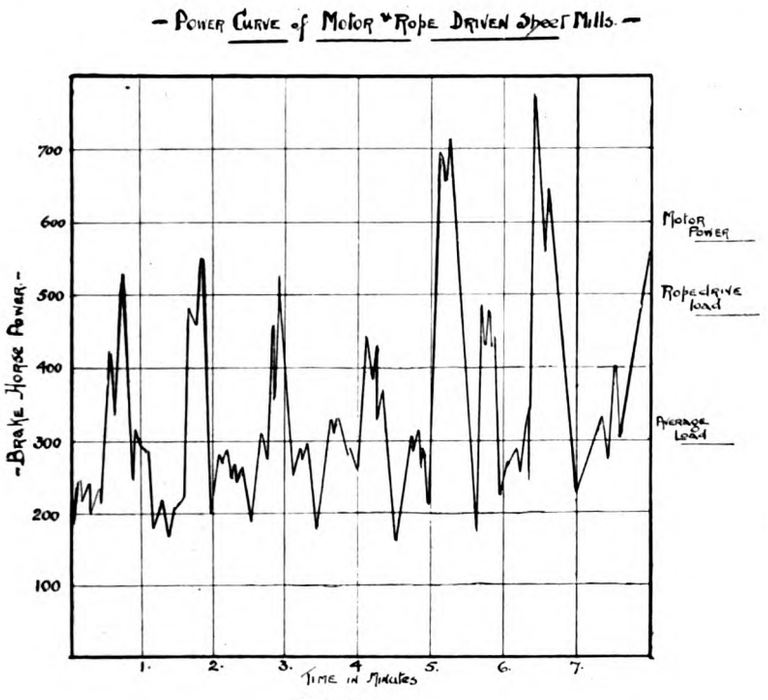

Fig. 3.

Perhaps the most apt illustration of a wedge-shaped medium is the drive on a motorcycle, where a V-shaped belt is fitted to a V-groove, without, however, the belt reaching bottom, yet obtaining the greatest possible groove contact and impact.

Longevity:—As to the life of cotton ropes much, of course, depends upon their size and the conditions under which they have to work. All things being equal, durability may be gauged by sectional area, and the most economical diameters range from 1½-in. to 1¾-in., more of the latter being used in England than any other size. For rolling mill work, however, it so often becomes a matter of sheave widths, that 2-in. ropes are generally used. A remarkable case of longevity may be mentioned of 24 cotton ropes 1¾-in. diameter employed to transmit 820 horsepower at a velocity of 4396 ft. direct from the engine flywheel 28 ft. in diameter,in a Lancashire cotton mill. These were fixed in September, 1878, and are still running in 24-hour a day service, a period of over 38 years. Another set has been working 28 years, on an average of 20 hours per day, and appear little the worse for wear. A good sample was removed from a drive after 10½ years service.

Such cases of longevity lead to the conclusion that fatigue of material due to constant activity does not readiliy manifest itself in well-made cotton ropes. Their quick recovery from driving strain is suggested as the cause, since they pull down on the working side and bulge out to their normal diameter immediately upon passing to the idle or slack side of the drive.

Short Centers:—For evidence of the fact that by adding sufficient rope to make up any deficiency in contact, driving may be sucessfully accomplshed when sheaves are almost touching, we need only refer to the case of an engine in Scotland, where spur gearing was removed and rope sheaves fixed on the same centers, permitting only a clearance of 8-in. between sheave rims. A load of 360 horsepower is comfortably transmitted with 16 ropes 1¾-in. diameter. At a mill in the north of France the sheaves are so close that a finger would scarcely pass between them.

At the present time a drive is being fitted for the Armstrong-Whitworth Company of Canada, at Montreal, in which the sheaves are 108-in. and 72-in. on a rolling mill plant, with only 15-ft. centers and grooves for 12 1¾-in. ropes. This drive is being fitted under guarantee of maintenance from the ropemakers, who originally were consulted on the scheme.

Over Roping:—Over roping certainly retards efficiency. The fault sometimes manifests itself by the slack changing with the pulling side, and at other times by the ropes traveling across the grooves or even leaving the pulleys altogether. When

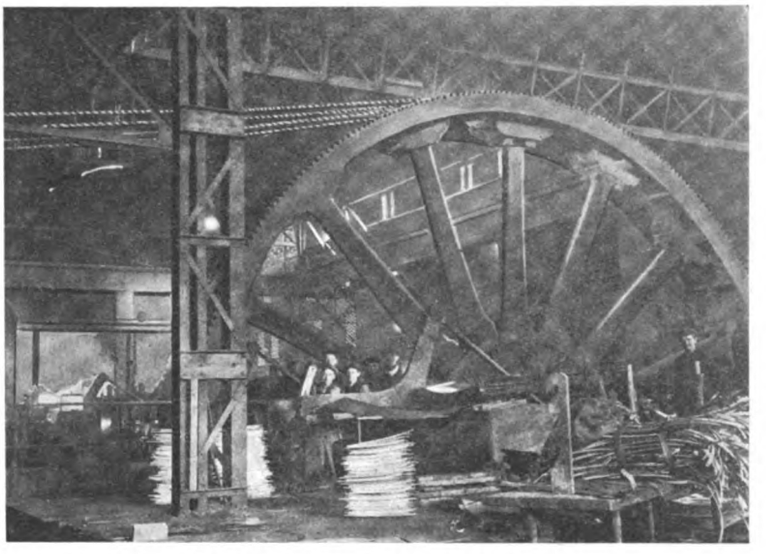

Fig. 4.—Mill sheave, 36 ft., diam., 150 tons, in hot roll drive.

such troubles arise it is best to remove one or several ropes if need be, without interfering with the splicings. Pass them over both pulleys and tie them well back to avoid revolving shafts. They can then be readily put back to work as the others give out. We have known

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instances where half the original number were taken off before satisfactory driving was obtained. This state of things frequently arises, even under fairly regular loads, when actual requirements come below the calculated

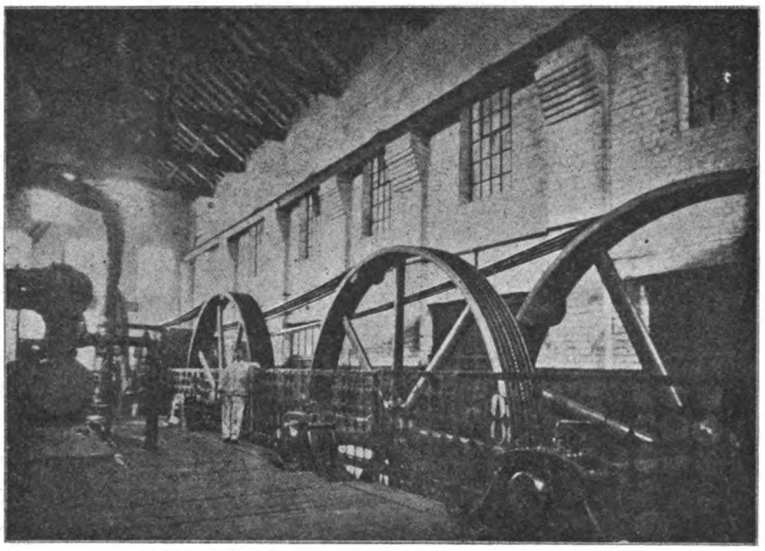

Fig. 5.—Three train cold roll drive.

power.

While an effective working tension of about 200 pound per sq. in. of rope section may be calculated upon, this figure may, in some cases, be profitably exceeded. To quote an instance, a large sheet rolling mill, when first installed, was driven by 26 ropes 2-in. diameter by electric motors and to provide against a peak load of 1500 b.h.p. was helped by the momentum of two heavy fly wheels making 35 r.p.m. or a peripheral velocity of 3516 ft. Tests conducted under working conditions revealed a high rate of resistance, which dimished as the load rapidly advanced from 150 to 900 horsepower. This was considered due to over roping at the lower power. Six of the ropes were accordingly removed. Running with only 20 ropes lowered their average friction from (say) 5.8 to less than 3 per cent, brought about steadier transmission, and materially improved the output.

Over or Under Driving:—While it is, and has been, generally accepted that the slack side of the drive should come on top, this position is not always obtainable, nor is it under all circumstances desirable. With an erratic or fluctuating load such as is obtained in rolling mill practice, we recommend the slack to come on the bottom. The variable load of the mill tends to set up considerable oscillation in the ropes and if the slack is above, may cause the ropes to ride or even jump off the sheaves. on the other hand, if the slack is below, any tendency of the rope to wander from its appointed track is held very largely in check by the pull on the tight side, also gravity and the weight of rope will control the oscillations. If, however, ropes persist in wandering from their appointed track. we recommend the erection of a rope guard, in comb fashion, which should be placed approximately 10 per cent off the centers away from the driven sheave. In rolling mill practice in England this is very freely adopted.

Sheave Diameters:—Sheave diameters have a very important bearing upon the question and while in England the minimum standard is taken as 30 times the diameter of rope, in America 40 to 50 times is accetped. Here again cotton scores over manila, since its softness readily admits of superior bending properties which the native harshness of manila and almost entire absence of resilience compel a higher minimum sheave diameter to which ropes of this material can be bent over. A power table has been calculated upon an average contact of 170 deg.

Centrifugal Force:—Groove impact also acts in opposition to centrifugal force, which has proved so potent a factor in belt driving, that whatever is done by way of compounding with narrower belts, adhesive dressings, or squeezing out the inevitable air-cushion, it will assert its retarding influence at a velocity fixed roughly at about 3000 feet per minute. when the power calculated on the basis of width must

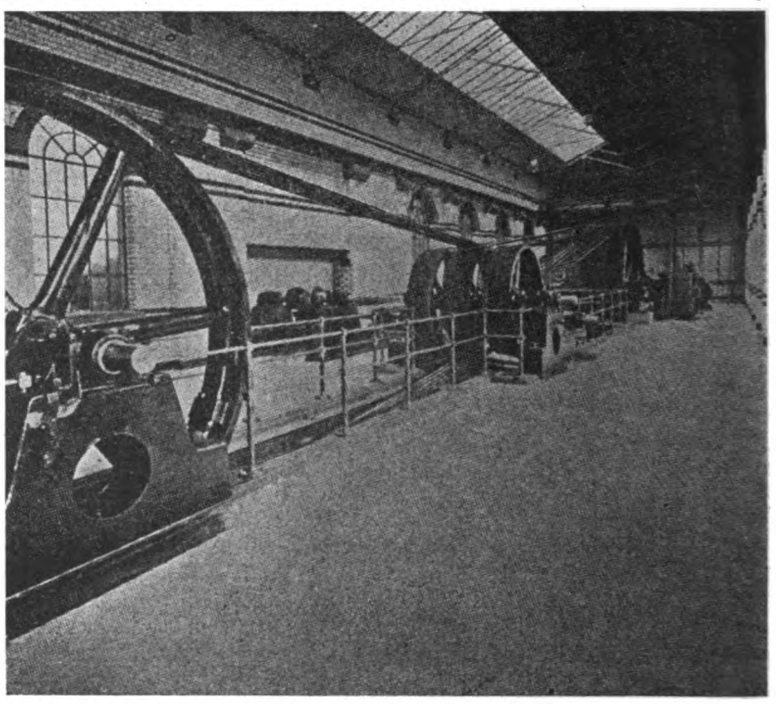

Fig. 6.—Wire rod mill drive.

be discounted in proportion to the increase in speed.

As affecting the rope drive,' however, many tables are compiled whereby a steady decrease of transmitted power over 4800 feet per minute is shown, until we

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find ropes at 7000 feet capable of transmitting only half the load of the same rope at 4800 feet.

While few cases of rope transmission exceed a velocity of 5000 feet, possibly because of the necessitiy for specially constructed sheaves, those of higher speeds totally disprove the theory of centrifugal detraction at the higher velocities, but rather reveal a larger ratio of increase. We have drives in England and France running at over 7000 feet per minute, and transmitting the higher calculated horsepower, but I think all are outdone by a drive which I encountered in Cleveland where the ropes are running at 7800 feet per minute. The driving sheaves is 14 ft. 4 in. diam., making 168 rev. per min. with driven sheave 4 ft. 7 in. diam., and fitted with 19 2-in. ropes to transmit approximately 1400 horsepower. The driven sheave only shows a 27½ times diameter of rope but is giving comparatively good service. This will prove a unique illustration to friends in England, but seems to leave us farther in the dark as to centrifugal force.

Effect of Moisture:—Cotton ropes are also less susceptible to atmospherical changes than manila for the reason that moisture more readily evaporates through the fibers, thus rendering them practically immune from internal mildew which so often is apparent in a discarded manila rope.

Inter-Stranded Cotton Driving Rope:—Allowing the claims I have put forward in favor of the three-strand rope, without further advocacy of the general principle involved, it may be logically contended that if such a rope possesses constant equality throughout, if the yarns are equal in counts, number, tensile strength and tension, each one following its appointed track without deviation, and are all of the best procurable quality, then we have arrived at a point bordering on perfection in the making of driving ropes, and their manufacture and application has been a close study for over 50 years.

This rope is made expressly for power transmission, from the finest selected American yarns. Each of the three strands is made up of a succession of sheaths or layers of yarns, which may be peeled off until the center thread is reached. The rope is machine built, under hydraulic tension, so that a perfect and combined tension is secured to each thread, from the moment these threads are led to the machine. The crinkling effect to be found more or less in all rope made by the ordinary method is thereby eliminated.

As previously mentioned, the triangulation of strains is secured in three strand ropes and in this particular rope is maintained to the individual threads. In effect this construction means that with the rope at work each thread takes its relative proportion of duty and again in wearing only the external layer will show abrasion, leaving the next layer intact. This feature is of significant value, since I could quote to you many instances, where say a 1¾-in. rope, after years of work is reduced in diafeter, but has still sufficient life left in it to enable it to be removed to a drive where ropes of about 1½-in. diameter may be in use.

There is no limit to length in constructing this rope other than may be controlled by convenience in transportation.

Splicing:—All that I have said relative to the making of cotton driving ropes and their application to transmission of power would be of little value without some reference to the question of splicing.

This is so important to the well-being of the system in general that rather than have installations spoiled by indifferent workmanship expert splicing mechanics, properly trained to this duty, are sent out from England to all parts of the world.

We have experimented with different devices of metal and other couplings, with a view to dispensing with splicing, but nothing has yet been found, which, in England, would be considered against the long splice. This is usually calculated at about 82 times the diameter of the rope. I wish to offer you some comparative examples of rolling mill work, with relation to the life obtained from cotton rope in England.

An installation with which I was personally associated was fitted with 18 ropes 2-in. diameter on a driving sheave 10-ft. 6-in. diameter at 110 r.p.m., and a driven sheave 30 ft. diameter at 38.15 r.p.m. With this peripheral speed of 3636 ft. per minute the ropes were calculated to do 846 horsepower, allowing a fair margin of safety, and leaving a balance of 154 horsepower, or about 15 per cent, upon a momentary peak load of 1000 horsepower to be carried through by the momentum of the fly wheel. This was on a 6 stand hot roll tin plate mill. Here the ropes lasted 7 years, but underwent various hardships, such as standing in a flooded pit for 2 weeks, and were also subject to some very inferior take-up splicing because the proprietor would not face a few dollars expense to have the work done by an expert. Fig. 3 is a power curve for a drive of this character.

This layout need be reckoned favorable to long rope life, although it was due to the instigation of the rope-makers that the number of ropes was increased from 14 to 18, after careful calculation of the relative average and peak loads.

Fig. 4 is an illustration of the mill in another hot sheet mill drive, where 16 2-in. ropes are employed to drive a 6-strand plant. The engine is of the "Uniflow" type with driving sheave 8 ft. diameter at about 145 r.p.m. and a mill sheave 36 ft. diameter and weighing 150 tons, making about 33 r.p.m. While this drive has given fairly good rope life, in that the present ropes are on as installed in September, 1910, the over run of the heavy mill wheel appears to cause a very heavy lashing of the ropes at starting and stopping.

In 1908 a sheet mill drive, was put down in the north of England by a firm which had considerable ex-

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perience in continental practice. In this 25 2-in. ropes were fitted to drive a load varying from 750 to 1000 horsepower and at times reaching even more than this, at a peripheral speed of 3400 ft. with sheaves 6 ft. and 30 ft. diameter respectively. The original ropes are still doing duty and more recently the plant has been duplicated.

Fig. 5 is of a 3-train cold roll drive, each with 6 2-in. ropes, running from a driving sheave 10 ft. diameter weighing 15 tons at 80 r.p.m. on to driven sheaves of 16 ft. at centers 31 ft., 43 ft. 6 in. and 59 ft. 6in. There are a large number of drives similar to this in England and Wales, and all may be said to give excellent rope service, varying from 10 to 15 years.

Another opinion held by one of our largest consulting engineers in England with steel mill practice, is that the rope driven mill will produce a better finished sheet than will the gear mill.

I am sorry to say that one of the first rope driven sheet mills to be installed in South Wales is not to be reckened as giving ideal conditions for rope. Thanks to a misguided erection foreman, the shafts were laid down out of line and to-day No. 1 rope on driving sheave runs into No. 2 groove. The driving sheave, 8 ft. diameterr, is grooved for 24 2-in. ropes, with driven sheave 28 ft. diameter. Considerable difficulty was experienced in keeping the ropes in their grooves, no doubt due to the faulty alignment, so the number was reduced to 16 and a rope guard fitted, and the present set has been on now about 7 years. Here they are driving a 5-stand plant, with 2 on one side and 3 on the other side of the mill wheel.

In another drive six 1¼-in. ropes are employed to drive two 15-in. sets and one 7-in. set of rolls. The different rolls are mounted as they may be required for manufacturing tin bars, light rails, merchant bars, etc. The driving sheave is 18 ft. at 100 r.p.m. and the driven 6 ft. diameter. The duty is represented at 350 b.h.p. from a 400 horsepower engine. This drive is very satisfactory and gives a long rope life.

Fig. 6 is a rope driven wire drawing mill at William Cooke's Mills in Sheffield, which has proved a highly successful installation.

The rope speed would be about 5000 ft. per minute with 1¼-in. ropes driving forward to two lines of rolls, with the engine shaft taking the other. About two years ago, I had to inspect the drives, the engineer being afraid one set of ropes was giving way. The whole of the drives was doing splendidly in spite of their seven years continuous night and day service.

METALLURGICAL CHART.

Blue-print copies, 2 by 3 ft., of the chart appearing in the July issue of The Blast Furnace and Steel Plant, under the caption of "Graphical representation of the sequence of the various processes in the manufacture of iron and steel," may be secured from E. E. Sanborn, Ohio State University, Columbus, Ohio, for 25 cents per copy.

Sulphur as a Component of Furnace Slag

Free and Sublimated Sulphur—Causes of High Sulphur Iron. Relation to Various Furnace Conditions Such as Hearth Temperature—Fusion Zone and Furnace Driving—Effect on Slags.

By WALLACE G. IMHOFF.

The causes of free sulphur are many. Some of the most important are to be found under the following classification:

1.—Too much sulphur going into the furnace.
2.—Too much lime.
3.—Too little lime.
4.—High fusion zone.
5.—Water.
6.—Low hearth temperature.
7.—Cold air.
8.—Too much wind.
9.—Accumulated sulphur.

It is seldom found that too much sulphur goes into the furnace in ordinary furnaces using lake ores. On such furnaces practically the only source of sulphur, of any quantity, is in the coke. The same cannot be said in regard to merchant furnaces, for at times, there can be no doubt, that too much sulphur goes into the furnace. The sulphur in the iron cannot then be removed in sufficient quantities to lower it within the desired limit.

A burden made up of high sulphur ore will at times require the complete removal of such ores, before the furnace will again make low sulphur irons. It is not infrequent in such instances to put in an ore which will wash or thoroughly clean out the furnace at this time. A large unfluxed charge of heating cinder is often used, sometimes from ten to twenty thousand pounds of gravel, and often just a good dose of sand. In any instance the purpose is to cleanse the furnace and make it drive faster, smoother and produce better iron.

Too much lime is one of the most common causes of high sulphur iron, which of course means free sulphur in the furnace. It is generally known that lime fluxes and removes the sulphur but in practice it is not so thoroughly understood that too much lime will

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cause still further rise in sulphur rather than lower it. A great many causes are responsible for free sulphur iron, so that when the time is at hand to do something, the one in charge should know the right thing to do and the right time to do it.

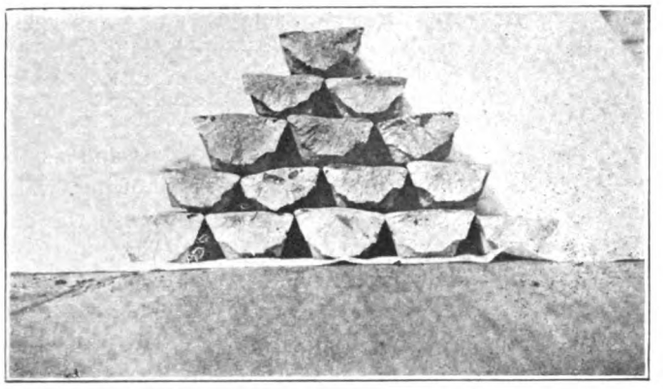

Fig. 1.—Iron samples from a too-heavily limed furnace. Note the arched tops, blow holes, and white steel like fractures.

The following example of iron and cinder show a furnace with too much in it.

Iron.

Cast time.	8	4	9	5
Silicon	.40	.34	.26	.31
Sulphur	.048	.112	.237	.195
Manganese	.43	.29	.27	
Phosphorus	.152			

Cinder.

SiO_2	Al_2O_3	CaO	MgO	Fe	S	Tot. Base
32.20	13.10	45.10	6.43	.56	1.35	51.53

This furnace has about 3½ per cent too much bases for the other components of the slag. To have regular driving with good results the bases required to form the proper slag relation with 32.20 and 13.10 Al_2O_3 should be about 48½ per cent; or turning the relation around it would require the silica to be about 22 to 25 per cent in order to have regular uniform driving with 51.53 per cent bases, the alumina remaining the same.

Now just what happens with too much lime on and how can this fact be seen from this slag analysis? At all times the hearth temperature determines the character of both iron and cinder. Two very prominent general facts are known, high silicon low sulphur irons are usually made when the hearth temperature is high and the fusion zone low, and very low silicon high sulphur irons are made on a cold bottom and high fusion zone.

With these two facts in mind we will now see how and why too much lime raises the sulphur in the iron, or in other words why we have an excess of free sulphur under these conditions. The 8 o'clock cast already shows extremely low silicon and fairly high sulphur, .40 and .048. Lime is extremely hard to melt and has a very strong attraction for silica on a cold bottom. The colder the bottom the less silicon in the iron, the more silica in the slag. Now as the silicon is lowered in the iron, or rather as less silica is reduced the greater becomes the necessity to flux the silica. Under such conditions the iron has a stronger attraction for the sulphur for it takes heat to give low sulphur irons.

As the bottom continues to grow colder more and more sulphur is released from the lime and the incoming sulphur remains unfluxed and free to go into the iron. Thus the next cast shows .34 silicon and .112 sulphur with the bottom still growing colder. Finally at the 9 o'clock cast, the lime has brought silicon down to .26 and the sulphur has gone to .237. The bottom is extremely cold and the lime has made such a thick infusible cinder it cannot be removed from the furnace.

Fig. 1 shows samples of iron of this type. The grain, if it has any is close, the samples are still white, the tops are arched, the iron full of blow holes and covered with blisters. Two facts stand out prominently, the bottom is cold and there is too much lime on. The lime can not be removed at once for it takes 8 to 12 hours for a change to go through the furnace. Extra coke requires the same time to become effective so that a change by either cannot immediately reach the source of trouble.

The immediate remedy is the wind. The bottom may be heated up with stoves or by cutting back the wind until a change of burden reaches the hearth. Lime should be removed at once and such changes made as will bring about normal working conditions as soon as possible. The main characteristics of too much lime than ore,—very low silicon and high sulphur.

Just the opposite is true with too little lime, high silicon and high sulphur irons. The following analyses of iron and slag show the shortage of bases.

Iron.

Silicon	1.80	2.09	1.78	1.11	1.50	1.11
Sulphur	.055	.047	.038	.088	.045	.074
Manganese	.69	.79	.73	.....	.75	.....

Cinder.

SiO_2	Al_2O_3	CaO	MgO	Fe	S	Tot. Base
36.32	12.44	42.00	6.19	1.14	1.39	48.19

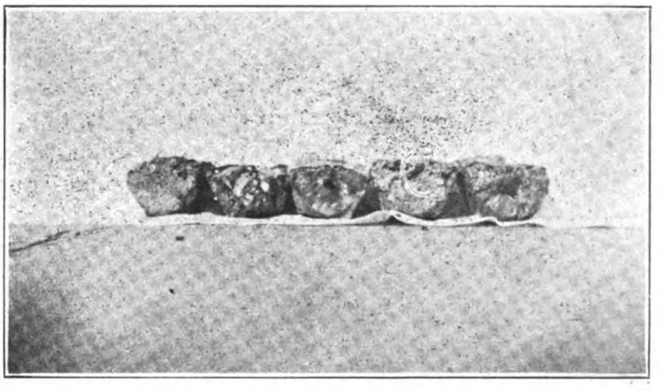

Fig. 2.—Black glassy water slag samples.

The above analysis shows conditions which should have required 52 to 53 per cent of bases, or in other words there is a shortage of from 3½ to 4 per cent of bases.

Since there is high sulphur in both cases how can

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you tell the difference? The first has about 3½ per cent too much lime, the second has about 3½ per cent too little lime. The difference in the second is that the silicon in the iron is high and also the silica in the slag is very high. To get low sulphur iron with the same

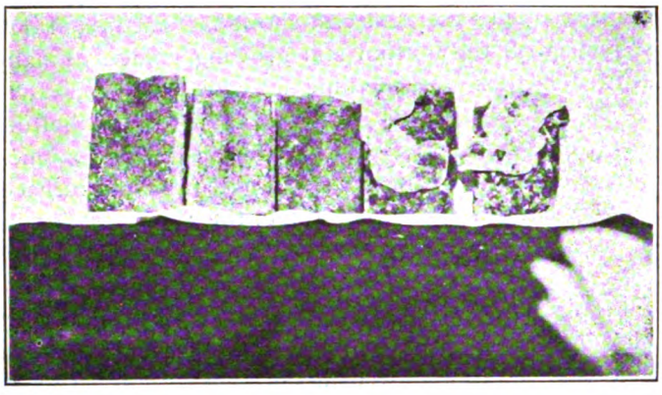

Fig. 3.—This illustrates "slag creep," caused by the escaping of free sulphur gas when the slag is cooling. Also note the white ragged edges on the iron samples caused by sulphur.

mix the silicon would have to be about 4 or 5 per cent in the iron. This would reduce the silica in the slag and at the same time automatically increase the lime which would flux the sulphur. Conversely with a drop of silicon in the iron the silica increases by almost double in the slag, which requires lime to flux it and leave the sulphur free to go into the iron as seen from the above analysis. As seen from the silicon here the bottom is not cold, so that the remedy is merely to put on more lime.

Often the sulphur seems to be very high with plenty of lime going into the furnace. This can actually be a fact that there is plenty of lime going into the furnace and still the sulphur be pretty high. The cause may be indirect but the result is the same, namely a high fusion zone. It takes more lime to run a furnace on a high fusion zone than on a low one. This is seen by the change of furnace conditions when the fusion zone comes down into the hearth, there is then too much lime on. The indirect causes are these, cold air, or too much wind both of which will raise the fusion zone. Cold air has the tendency to separate the lime thus freed which combines with the silica and the sulphur is canned out as free sulphur. Too much wind has the same effect, namely to make the lime combine with the silicon and let the sulphur be removed as free sulphur in solution in the slag. Basic slags always show lots of free sulphur due to the fact that cold air is run in, to hold down the silicon within the desired limit.

Large quantities of water also cause high sulphur iron and produce free sulphur in the furnace. From time to time small amounts of water, may enter without doing material harm, then just as soon as the opportunity comes as for instance cast time, this may be stopped.

One of the indications of water is a black glassy cinder. If it enters the furnace in large quantities it will be shown by the iron. The following analyses show a furnace taking in considerable water from the mantle pipes.

Slicon		Sulphur
2.14		.022
2.09		.033
1.58		.058
1.30		.089
1.47	Water stopped	.030

The slag was an ink black glassy slag and as the water increased the bosh lighted up showing water gas. Just as soon as the water was stopped the sulphur immediately went down to .030. Figure 2. shows black glassy water slag samples.

It is extremely interesting to study in detail the characteristics which accompany the various types of iron and slag. Each individual component has its own markings and can be deciphered if only time and care are taken to do it. For example in figure 3 the free sulphur has been the cause of the white part of the slag which has boiled out and ran over the top of the slag samples on cooling. The hot liquid slag held this free sulphur gas in solution but on cooling it tried to escape causing the slag to boil out and run clear off down over the side of the sample box. This particular feature has been called "slag creep" by the writer because the boiling out and running out of the cinder resembles the creeping of water or other liquids when running free.

The free sulphur is seen in the iron samples by the hard pure white edges. Sulphur also makes the edges ragged as seen from the edge of the outside iron sample.

The prominent fact which is one of the most important features of free sulphur is its relation to the gas cavities in slags. Most all if not all gas cavities in slags are caused by the escaping of free sulphur. In

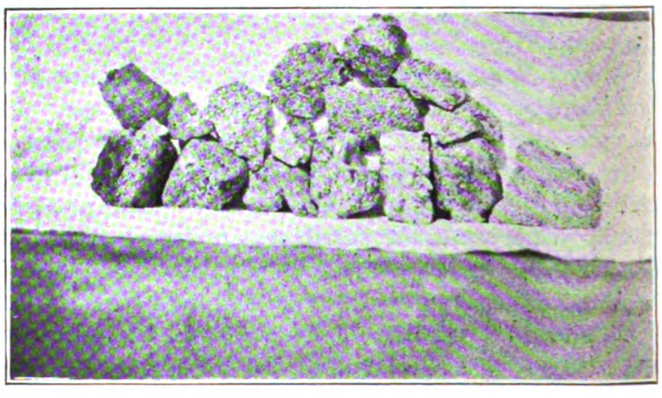

Fig. 4.—Gas cavities caused by free sulphur gas. Medium lime.

rare cases steam might cause such cavities when the furnace has taken considerable water but the general cause of such cavities in any slags which are limy or lean can be directly traced to sulphur.

Fig. 4 shows various slags of medium lime with

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extremely small holes all over them. These holes or gas cavities have been caused by free sulphur gas. With heavy lime the gas cannot escape so easily and therefore as the slag cools the gas finally forces itself out and developes the "slag creep" shown on top of the sample

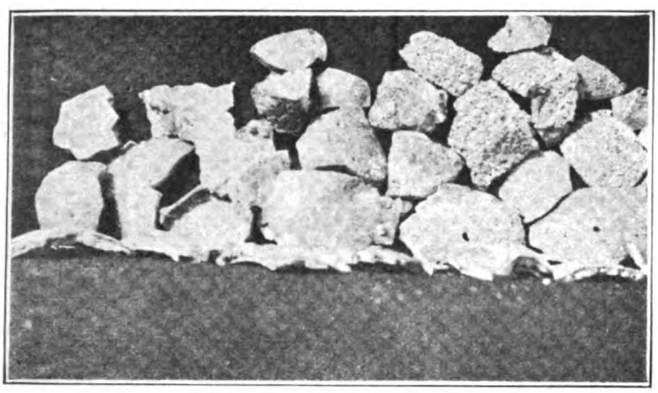

Fig. 5.—"Slag creep" and gas cavities in fairly limey slag, due to free sulphur.

of figure 5. Note the escaping gas has also left the inside full of gas cavities and very porous looking. This type of slag would show high combined sulphur also the "creep" and cavities merely indicating that there was still considerable sulphur free which escaped and forced its way out as the slag cooled.

Fig. 6 shows pieces of the dipper crust from combined sulphur and free sulphur slags. On the left the crust is solid and there is very little indication of free sulphur; on the right the crust is porous and full of cavities due to free sulphur.

We are now ready to give a short general discussion of one of the most interesting phases of free sulphur, —"buckshot." What is buckshot? What causes it? and how can you stop it? These questions and many more will be answered in a special article devoted entirely to to this subject, it is sufficient to say here that "buckshot" is mechanically unseparated slag and iron, caused by an extreme excess of free sulphur. It consists of a slag matrix filled with iron shot which have been caught and held in the slag and it is not unreduced iron as many furnace men have thought it to be. Unreduced iron is some form of iron oxide but "buckshot" is metallic iron shot entangled in the slag. It is not an uncommon thing to find that the driving of the furnace slows down as the amount of free sulphur increases. The following typical example shows such an instance.

Cast Iron Hour	Iron Silicon	Iron Sulphur	Charges Day	Charges Night
8 A. M.	1.00	.030	10	9
1 P. M.	1.07	.032	10	9
6 P. M.	.97	.036	10	9
11 P. M.	1.01	.041	10	9

During the day the furnace took 10 charges every three hours, at night with a continued rise in sulphur the driving slowed down to 9 charges every three hours.

High free sulphur may also be caused by heavy bottom slips. This iron when there is extra coke in the furnace is also high silicon, high sulphur iron, and should not be confused with high silicon, high sulphur iron due to a shortage of lime. Good examples of such iron due to heavy bottom slipping are seen by the following analyses.

Iron

Silicon	Sulphur
1.29	.052
1.17	.061
1.45	.040

It is very difficult to interpret furnace conditions from slag analysis alone. It can be done but many detailed facts have to be known about slags in general and conditions under which they are made. For example two sets of analyses almost exactly the same will be given, the one showing basic iron and free sulphur, the other showing foundry iron and combined sulphur. It is obvious to those familiar with the details of successful blast furnacing that two grades of iron cannot be made from the same slag analyses with continued smooth operation. Note that these two sets of slag analyses are almost identical.

Basic Iron—Free Sulphur.

Iron Silicon	Iron Sulphur	Cinder	
.88	.034		
.89	.035	SiO_2	34.92
.68	.033	Al_2O_3	13.48
.68	.060	Bases	49.32
.75	.049		
.77	.036	Total	97.72

Foundry Iron—Combined Sulphur.

Iron Silicon	Iron Sulphur	Cinder	
2.22	.020		
1.80	.023	SiO_2	34.84
1.39	.034	Al_2O_3	13.18
1.30	.029	Bases	49.57
1.47	.028		
1.48	.027	Total	97.57

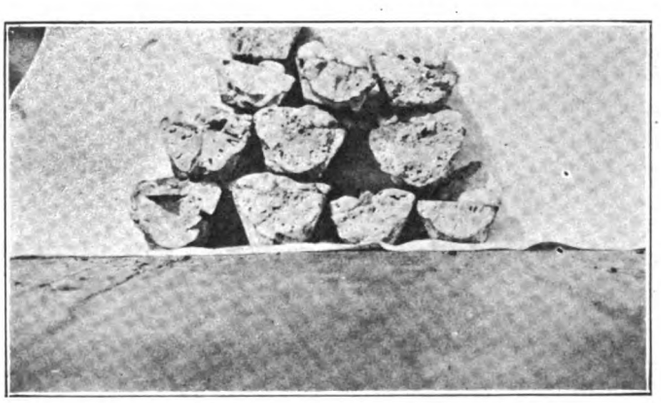

Fig. 6.—Dipper crusts. On the left few gas cavities, sulphur combined; on the right free sulphur and lots of gas cavities.

It is seen that the basic iron has sulphur beyond commercial limits and therefore such a slag is not suitable for making basic iron. A slag with 34.92 SiO_2, and 13.48 Al_2O_3 should have at the very least 53 per cent of bases to hold the sulphur within the desired range.

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The relation between the silica, alumina, and bases is definite and cannot just be anything. Each component of a slag has an absolute definite value to maintain equilibrum under certain given furnace conditions. This value is not suitable for other furnace conditions and therefore when one changes, the other must change. When conditions are forced then the furnace "goes off" and continues to give trouble until this equilibrium is again established.

There is usually some free sulphur in the furnace. It is seldom that everything is balanced or in other words that there is complete equilibrium and all the sulphur is combined with the lime as lime sulphide. At times, especially on merchant furnaces with high sulphur coke and ores, there seem to be very large quantities of sulphur removed with the outgoing gases. The stack fumes show a heavy discharge of thin blue smoke, and at flush time the blue smoke rising from the cinder runner is suffocating. Actual figuring also shows that taking all the sulphur in the iron and slag there is a very great defficiency under the total amount going into the furnace.

Large excess amounts of free sulphur have the tendency to give a gas of poor quality. The reason is that there is a tendency to keep the carbon in the combined form, which in turn diminishes the supply of carbon available for the gas.

The question has often been discussed as to whether sulphur can accumulate in a furnace. The answer is yes it can, by having on too dry a mix and making very low sulphur iron. The inside builds up with accumulated dry cinder. Then just as soon as conditions change or a large amount of silica cuts out this material the lime is fluxed and the accumulated sulphur set free to enter the iron.

A low hearth temperature will almost invariable give large amounts of free sulphur. This is due to the fact that the silica remains unreduced and takes the lime to flux it, leaving the sulphur free to enter the iron. Or perhaps the same thing may be stated in a little different way; under these conditions the iron has a stronger attraction for the sulphur than the lime has.

Cold air is also one way of keeping the sulphur free. Free sulphur does not necessarily mean high sulphur iron. For example often after an extra coke, blank cold air will be run in to keep the furnace driving. The real reason is, the silica is what makes a furnace drive and by running in cold air the silica is kept in the slag instead of being reduced to silicon and going into the iron. But the cold air also either separates the lime from the sulphur or else keeps it from combining with the sulphur and hence the suphur is canned out as free sulphur gas in solution in the slag. Such conditions give a thin fluid iron due to the fact that there is very little chance for the formation of graphitic carbon, which decreases the fluidity of iron.

Too much wind has the same effect in the slag and furnace conditions as cold air. It blows the bottom cold, raises the fusion zone and keeps the sulphur as free sulphur. If the wind is kept too high it is only a question of time until the furnace will "go off": and give trouble.

High free sulphur means that one or more of the various causes given above need to be adjusted. It is a question to know which, for the cause may be entirely different from the one for which a change is made. It is therefore important to know how to control each of the operations which effect the running of the furnace.

Something very unusual happens at times on furnaces with very large quantities of sulphur on the burden. The slag if solid, dry and grainy will show a yellow center. If studied closely this will be found to be nothing more than pure yellow sublimated sulphur. Often when pieces of slag are broken such sulphur may be seen as a yellow coating in the gas cavities. Such examples are rare on furnaces using lake ores but it is not uncommon at all to see the various slag samples on merchant furnaces be yellow from such deposited sulphur. Such slags when running will have a very thick greasy looking scum on the surface which is a peculiarity accompanying slag with extremely large amounts of free sulphur.

Rolling Mill Power Requirements

Difficulties encountered in the derivation of formulae—Interesting experiments showing flow of metal during rolling—Consideration of total mill load in continuous mill.

By F. DENK.

In The Blast Furnace and Steel Plant, of January, 1915, the author published two formulae for the calculation of the power required to roll steel, the one depending upon the logarithmic expression for the volume displaced, while the other one was based on the equation $V_d = (A - a) L$. Lately the arguments concerning the correctness of these two expressions for V_d seem to arise again, and, for this reason, it is well to remember, what has been stated in this regard in the above-mentioned article. It was also shown, that the hyp. log. formula is only a special case of the other one, i. e., of $V_d = (A - a) L$, in so far, as it expresses the displaced volume for an infinite number of passes. Neither of the two formulae is theoretically

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correct, but since, up to the present time, there does not exist a formula which takes care of the actual rolling conditions, we have to use whatever is on hand. Considering, furthermore, that the values obtained by the (A — a) L formula are smaller, and those obtained by the hyperbolic log. formula $V_d = A \times L \times$ hyp. log. A/a are larger than the volumes actually displaced, we can easily see, that there are really no

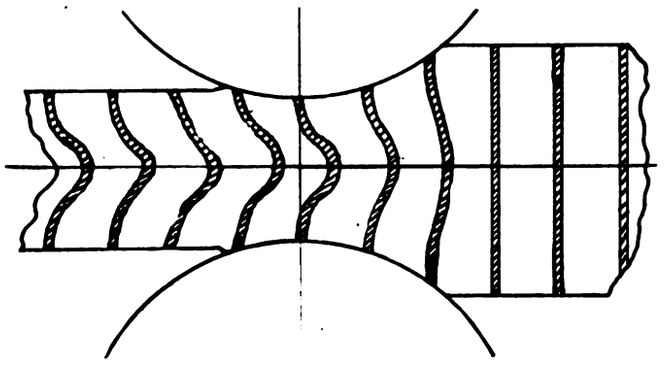


Fig. 1.—The lines indicate the deflection during rolling of wire nails inserted in a billet, thus showing the idrection of flow of hot metal during rolling.

reasons whatsoever for arguing which one of the two equations would give better results. In fact, applying them in the right way, will give identical results, as was also shown in the article mentioned, where the total power required was figured to be 80,200 H. P.-sec's, obtained from the (A — a) L formula, and 79,830 H. P. sec's obtained from the hyp. log. formula. In a later article more discrepancies in regard to the two equations were pointed out, which prove, that one is as wrong as the other one.

There is really only one reason, which speaks in favor of the equation $V_d = (A - a)$ L, and that is the simplicity of its application. It is certainly easier to work with square roots than with hyperbolic logs and, therefore, other investigations into the power requirements, made by the writer, have been based on this formula.

The equation for the power required to roll steel, derived by the author, and used in this article, is based on the (A — a) L formula and reads

$$A = C \sqrt{\frac{d \times R \times W}{S}} \qquad (1)$$

where

A = power required to remove one cu. in. of material at any draft "d," any roll radius "R," any ingot weight "W" and any rolling speed "S";

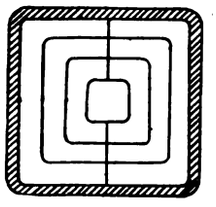
C = power required to remove one cu. in. of material at a draft d = 1", a roll radius R = 1 ft., an ingot weight W = 1 ton and a rolling speed S = 1 R.P.S.

The temperature of the ingot is taken care of in "C," the value of which, of course, varies inversely with the temperature. Curves showing the relation between the power required and the temperature of the ingot will be given later in this article.

The equation (1) says, that the power decreases, when the speed increases. This was proven also by Dr. Puppe in his articles in "Stahl und Eisen" Nos. 19 and 20, 1915. Later investigations, however, have convinced the writer, that this condition holds true only for speeds over about 35 R.P.M. For speeds lower than 35 R.P.M. the power required increases with increasing speed. But, since most of the rolling is done with speeds higher than 35 R.P.M. the equation given fills the wants and can be used. The actual conditions will be explained later on.

Equation (1) was investigated by Prof. C. Lang in Selmecbanya, Hungary, who published a formula of his own in "Stahl und Eisen," No. 1, 1916 (see also The Blast Furnace and Steel Plant, March, 1916). Prof. Lang comes to the conclusion, that his equation and the above equation (1) are identical in general.

But before explaining this identity further, a few data will be given, which will show the difficulty, or



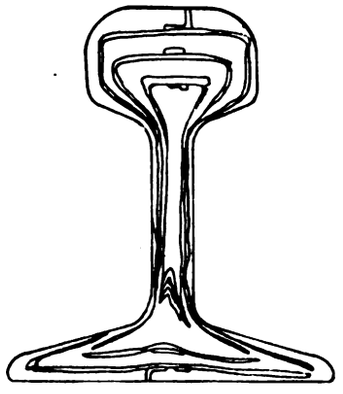
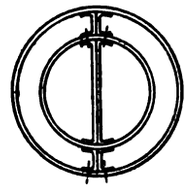


Fig. 2.



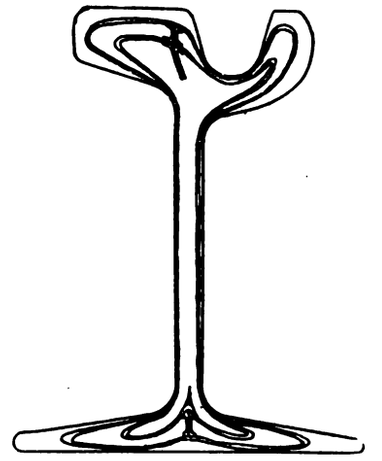


Fig. 3.

Result of experiments.—Showing flow of metal in rail sections.

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rather impossibility, of deriving a theoretically correct formula for the power required.

Early in the seventies of the last century Mr. Hollenberg, in Germany, made tests for the purpose of determining the power required to roll steel. He intended to derive a formula, which would allow him to calculate, as close as possible, the size of rolling mill engines, without having to resort to the "Hit and Miss" method, which was applied before. He drilled small holes in a billet, in which wire nails were inserted. The billet was then heated and partly rolled down. After cooling it was cut longitudinally in two pieces, in order to investigate the changes in structure, which might have taken place in the billet during rolling. The section is shown in Fig. 1; which shows, that the wire nails were bent in a direction opposite to the direction of rolling.

Hollenberg was the first one who pointed out the difference in velocity between billet and rolls. The velocity of the billet entering the rolls is smaller than the velocity of the rolls, while, when leaving, the opposite condition will take place. There must, therefore, be a point between the two limits, where the velocities of the billet and the rolls are the same. To determine the exact location of this point, however, is not possible, but it is mostly assumed to be about midway, or at least near to it, between the point of entering and leaving.

Having made exhaustive investigations into the matter, Hollenberg came to the conclusion, that, considering all necessary conditions, the derivation of a formula led to such complicated equations, that their practical application was impossible. To-day, after about thirty years of research work in this direction (not very much was done in the seventies of the last century) we are not very much farther advanced in this respect. This is in no way surprising, if it is kept in mind, that, in order to derive a theoretically correct formula, shearing stresses, velocities, tensile strength, and temperature of the material to be rolled have to be taken into account; that we must integrate not only in a longitudinal but also in a transverse direction, and that, besides the data for the material proper, the roll radius and other data from the mill have to be considered.

The difficulties encountered in endeavoring to take care of the flow of the particles inside a bloom or billet, when going through the rolls, can easily be seen from Figures 2 and 3. On the right side of both illustrations a section of a rail is shown, having a number of divisions in the inside. These divisions were obtained in the following manner: A section or skeleton was made up of small flat irons and angles or channels (see Figures 2 and 3 on the left), and these skeletons were then placed inside the ingot mold, and the metal poured over them. After the two ingots were rolled down to the required section the ends, which contained the skeletons, were cut off and edged. They showed the lines illustrated in Figures 2 and 3 on the right. (These experiments were made in Germany in the eighties.) The lines represent the original skeletons in a completely deformed condition. To derive an equation for such conditions will hardly be possible.

Hollenberg was followed by other investigators, but they all came to practically the same conclusion, viz., that it is impossible to derive an equation which takes care of all the conditions, or which, in short, is theoretically correct. It was then tried, to base the formulae either entirely on data obtained from carefully conducted tests on rolling mills or to derive some kind of a formula by means of theoretical reasoning, and then to compare it with data from mill tests and insert a constant into the equation, which, naturally, would take care of the rest. The larger the number of tests considered, the wider will be the range for which the formula can be used, provided, of course, that the tests are made under different conditions of rolling.

All of these formulae, however, derived in one way or in another, hold good only for mills, which work with direct pressure, for instance for blooming mills, billet mills (as long as they roll no small angles, etc.), slabbing mills; they are of no value at all for structural mills or rail mills for the reasons given below. Even for billet mills, where some of the grooves have an oval or diamond shape, the equations become unreliable and in order to get reasonable results, certain percentages must be added to the figures obtained from the formulae. These percentages can only be obtained by practical experience and may vary to a large extent.

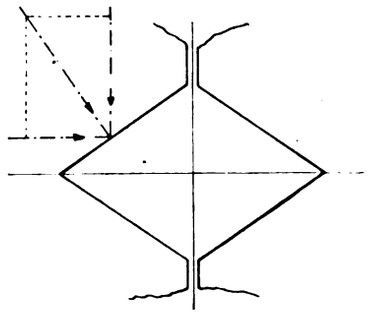

Fig. 4.

The proof of the statements made in the preceding paragraph may be seen in Figures 4 and 5. Figure 4 shows the diamond-shaped pass of a bar mill. The vertical load having been calculated theoretically, or the actual load having been determined by a test, it is easy to calculate the remaining forces on the paper. But if we compare these results with those from actual tests, we will find that the calculated values are far too small. This is proven by Figure 5, which shows data obtained from actual tests on a bar mill. Both curves run nearly parallel. It can be seen that the horsepower-seconds for the first four passes are nearly equal to each other for each billet, while the four last passes, and especially passes No. 6 on both billets are by far higher. This is due to the fact, that the first four passes are square passes, while the last four are ovals or diamonds with a large side friction.

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Another drawback for using the equations for the calculations of the size of billet or bar mill engines, can be found by a careful study of Figure 6, which represents tests made on a bar mill. On the top of

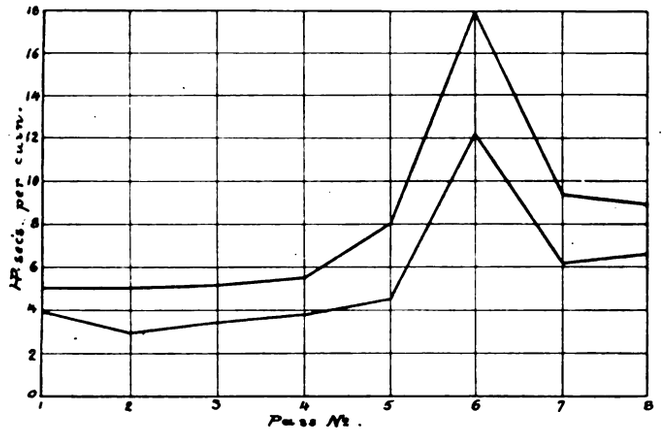

Fig. 5. — Power requirements for different shape passes; the first four passes shown are square passes, the last four are ovals or diamonds.

the figure the lengths of the different passes are shown, passes Nos. 1, 2, 3, 4 and 5 belonging to one billet or bar, while passes Nos. 6, 7 and 8 belong to the preceding one. Passes as well as billets overlap, that means, several passes, for instance, 1, 2, 3, 4, 6 and 7, or the first four and 7 and 8, etc., are working simultaneously and, furthermore, two billets are in the rolls at the same time. Now, it could be assumed that the total mill load, as shown below the passes, varies directly with the increase or decrease of the number of passes which are worked upon at the same time. But this is not the case. The curves, which represent an average from six billets tested, show at the left side a certain H. P. for passes Nos. 6 and 7 (about 850 H. P.). Whenever the billet enters a pass, this H. P. increases, as should be the case, until we come to the point, where the billet leaves pass No. 6. Here, at "a," the total mill power increases further, notwithstanding the fact that there are only five passes working (1, 2, 3, 4 and 7), while there were six working before (1, 2, 3, 4, 6 and 7). Then, shortly after, when the billet enters pass No. 8, the mill load drops instead of increasing. Similar conditions can be found at the points "b," "c," "d" and "e." There is hardly the possibility of an error having been made, either in making the tests or in working them up, because these conditions have been found to prevail with every billet tested. If the total mill load is compared with the actual friction load (about 400 H. P.), which is represented by the dotted horizontal line, it can be seen, that the power required for some of the passes should be zero or even negative. This, of course, is impossible. If the load for the different passes is calculated separately and is then, for the different passes which are working simultaneously, added up and if this sum is subtracted from the total mill load, we obtain the probable friction load, which is represented by the broken dot-and-dash line. Wherever there is a discrepancy as described above, this friction line will be high above the actual friction load with the one exception of point "e," where it falls a little below. At all other points the two friction loads are practically identical. For this reason we may believe, that the discrepancies are due to some conditions adherent to the mill proper, perhaps to a temporary screwing down of some of the rolls. Similar, or even worse, conditions have been found by the author, while investigating tests made on a bar mill outside the Pittsburgh district. Both these

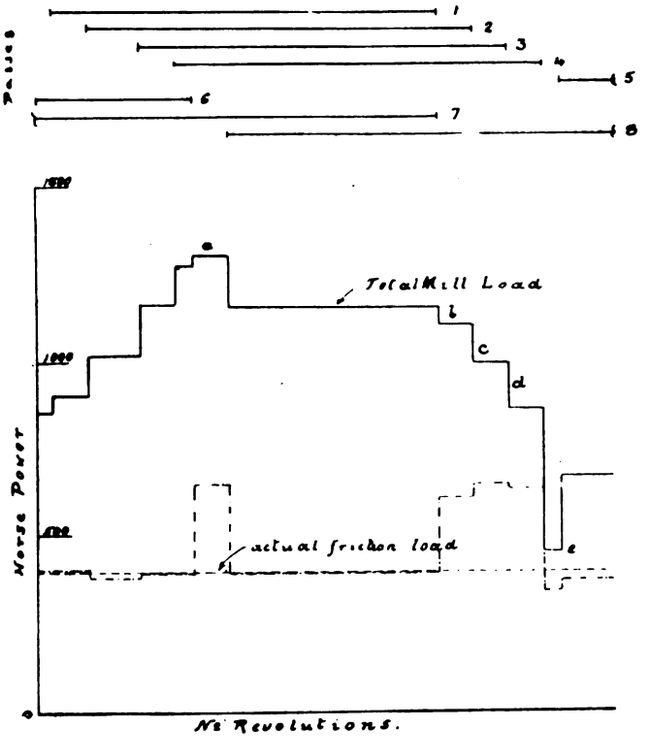

Fig. 6.—Tests made on bar mill showing variation of total mill load.

mills, the last mentioned as well as the one of which the curves are shown, are steam driven mills. This may also have something to do with the abnormal conditions, because tests made on an electrically-driven bar mill, which the writer investigated did not show any abnormal signs. In the latter mill, the mill loads increase and decrease with the increase or decrease of the number of passes which are worked simultaneously.

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Roll Pass Design for Standard Rails

Data and description of practice in several rail mills—Design of roughing, intermediate and finishing passes—Hot sawing of rail lengths—Cooling and reheating for finishing passes.

By W. S. STANDIFORD.

The manufacture of steel rails has reached a high state of perfection, due to the fact that the producers have availed themselves of every advantage that science and research could afford, and railroad engineers have learned from experience the qualities that are most desirable under modern traffic conditions. Perfection, however, has by no means been reached and the long list of rail breakages each winter, gives an approximate measure of the importance of the problems that are yet to be solved. In view of these conditions it is desirable to make a critical analysis of prevailing rail mill practice and roll designing methods, as a basis for future progress. Such an analysis is attempted in this article. Particular stress is laid on rolling practice, the melting problems being less complicated. Much of the writer's data is drawn from the Ohio works at Youngstown, operated by the Carnegie Steel Company.

The ingot is bloomed at the Ohio works on a 34-in. two-high mill, driven by a pair of 45x72-in. reversing engines with a hydraulic reversing gear. The top roll is carried by counter weights and is raised and lowered with a hydraulic screw-down. The blooming rolls are steel and have a 2½-in. hole in the center for the introduction of cooling water. These rolls are 57½ in. long with 18½-in. necks and have three grooves, 18½-in. 19½-in. and 7½-in. The ingot, which is 22x18 in., is reduced to a bloom 7½x8-in. in thirteen passes, as shown in the accompanying table:

Pass No.	Draft, Inches	Groove No.	Size when leaving pass. In.
1	2½	1	18 x 19½
2	2	1	18 x 17½
3	2⅛	1 edge	17½ x 15⅜
4	2⅛	1	17½ x 13¾
5	2⅛	1	17½ x 11⅝
6	2⅛	1	17½ x 9½
7	2¼	2	9½ x 15½
8	2¼	2	9½ x 13½
9	2¼	2	9½ x 11½
10	2¼	2	9½ x 9½
11	1	2 edge	9½ x 8½
12	1	2	9½ x 7½
13	1½	3	7½ x 8

It will be noticed that the drafts are heaviest in the first passes, getting lighter toward the last pass. Some rollers think that this distribution of the draft causes the steel to open up and crack more than if the drafts were light at first and heavier toward the last of the blooming, basing their opinion on the fact that the ingots have no fibre and are more or less honey-combed, in which state they do not hold together as well as after work has been done on them and their structure is fibrous and more compact.

Experiments at South Chicago.

Considerable experimenting has been done at South Chicago to determine what distribution of draft gave the best results. The ingot used in the South Chicago mill is 16¾x18½ in., and is reduced to a 7¾x8½-in. bloom in nine passes. The blooming mill is a three-high mill, so that each change in draft arrangement could only be accomplished by making new rolls, whereas on a two-high mill, the drafts can be changed with no expense by simply varying the distance the top roll is raised or lowered. After considerable experimenting, the South Chicago officials decided on the drafts they use at present, which reduced the percentage of seconds enough to more than repay them for the expense of the investigation. The following table shows the original distribution of drafts and that decided on by the experiments:

Pass No.	Original draft-Inches.	Present draft-Inches.
1	3 1/16	1 ¾
2	2 1/16	1 15/16
3	2 11/16	1 ¾
4	2 1/16	1 ⅞
5	2 11/16	3 ⅛
6	2 ⅛	2 3/16
7	2 ⅛	3 5/16
8	1 ⅞	2 1/16
9	1 11/16	2 3/16
Total	20 ⅜	20 ⅜

The design of the passes in blooming mill rolls is not such a difficult matter in a two-high as in a three-high mill, because in the former it is impossible to give the passes much shape, while in a three-high mill, the piece goes through each pass but once, and the pass can be shaped to the best advantage.

In all square passes, it is the aim to get as much side work on the piece as possible, to counter-act the tendency of the steel to shear. The latter is due to there being greater elongation on the top and bottom of the piece caused by the up and down work, than on the sides where there is much less work. It is impossible to get the elongation equal on all sides because it is impossible to have the work equal on all

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sides of a rectangular bar, except in a universal mill, but that condition can be more nearly reached in a three-high than a two-high blooming mill.

This shearing tendency, due to unequal elongation, besides being greater in a two-high than in a three-high mill, is not counteracted as much in the succeeding passes. In a two-high mill the piece goes back and forth two or four times before it is edged up and work done on the opposite sides, while in the three-high mill, the piece has work done on the opposite side in each alternate pass which tends to remedy the harm done by the unequal elongation.

The best that can be done, then, in designing passes for two-high rolls is to make the radii large and have taper on the collars, so that when the piece does fill the pass there will be work done on the corners and pass way on the sides, which will help to heal up the cracks. Aside from providing suitable radii in the corners of the passes and making the passes of the proper width to suit the drafts decided upon, there is little else to be observed in laying out the blooming mill roll passes, except the swell in the bottom of the grooves. This swell is put in the bottom of the pass to reduce the thickness more in

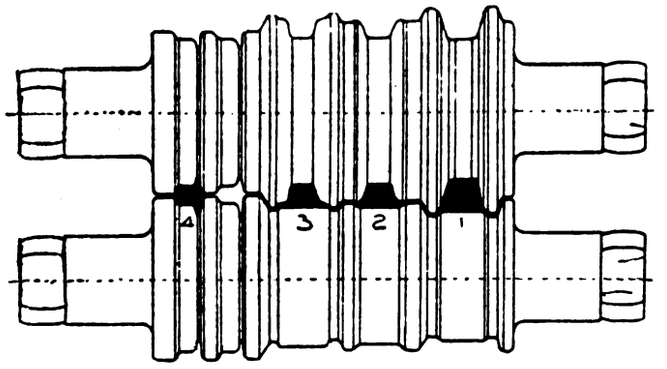

Fig. 1.—Roughing mills.

the center than at the edge, so that when a piece is edged up in the following pass, it will have room to spread without overfilling the pass, causing a seam that would carry through to the finished rail. The amount of swell depends upon the amount of spread the piece will have in the different passes, which is a variable quantity depending on the composition of the steel and the temperature at which it is rolled. The bloom coming from the mill is from 30 to 40 feet long, depending upon the length the ingot was poured, which is governed by the section of rail to be rolled. This long bloom on its way to the rail mill passes between the knives of the bloom shears, where the front end is lopped off back to the solid steel and then sheared into blooms of suitable length to make two or three rails, depending on the section to be rolled.

Designing the Rail Mill Passes.

The first six passes at the Ohio works are called the roughing passes and the last five the finishing passes. The finishing passes are laid out first, using the finished rail section for the starting point and working back through the other finishing passes, which will be different for each section of rail.

The roughing passes are designed to suit the size of bloom to be used and provision must be made to have them so constructed that different sections of rail can be made without changing the roughing rolls for each change in section. The most important thing in designing the finishing passes is to have the work equal in the head, web and flange; that is, to have the percentage of reduction as nearly equal as possible in the three parts of the rail. Every effort is made to do this, but certain requirements must be met, which makes it impossible to carry this out to the letter.

To get the exact area of the finishing or the last pass, the following calculation was made. The specific gravity of steel as given by good authority, is 7.854, which figure has been confirmed by experiments made with Bessemer steel at Joliet, Ill.

Weight per cubic inch = sp. gr. X 0.036085 (Kent, pg. 163,) hence weight per cubic inch = 7.854 X 0.036085 = 0.2832 pound.

A bar of steel 1 square inch in cross section and 1 yard long would weigh 36 x 0.2832, or 10.195 pounds; therefore, a rail weighing 70 pounds per yard would contain 70 ÷ 10.195 = 6,863 sq. in. The rail will have a greater area hot than cold. It is assumed that the steel, at the temperature at which the rail is finished, has an expansion of 3/16 in. per foot at least. In all rail mills hot templates are laid out with a shrink scale having this amount of shrinkage per foot and the finished rail is of the correct weight.

Now, if in a foot the shrinkage is, 3/16-inch, equivalent in decimals to 0.1874 in. to produce a cold bar 1 foot long we must shear the hot bar to a length of 1.01575 feet. Likewise a bar 1-in. square cold will be 1.01575 inches square hot and will have an area of 1.031 square inches. Since the area of the 70-pound section given above is 6.863 square inches cold, the hot section will have an area of 6.863 square inches x 1.31, or 7.075 square inches; the finishing pass was accordingly laid out to A. S. C. E. dimensions with a shrink rule having a shrinkage of 0.1875 inch per foot. This was done very accurately with fine lines on bristol board and the area gone over very carefully with a planimeter, which gave the area 6.99 square inches, showing a difference of only 0.08 square inch from that called for by the above calculations; in other words, the 70-pound A. S. C. E. rail is a trifle less than 70 pounds.

The other section also show slight variations. This then, is the design of the finishing or No. 11 pass, except that the flange in the closed roll is opened up 1/64-in. from a point ½-in. below the center line, which, besides allowing the rail to deliver free, makes the base of the rail a trifle concave, which is desirable. It guards against a convex base, a serious defect in a rail. Care-

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ful work with the planimeter showed that the 6.99 square inches of area were distributed as follows:—

	Sq. Inches
Head	2.92
Web	1.5
Flange	2.57

or in percentage;

	Per Cent
Head	41.77
Web	21.46
Flange	36.77

It has been the aim in the remainder of the passes to keep the distribution of area as close to the percentage of the finished rail as possible after meeting the other requirements in the design. How successfully this has been done will be seen by referring to the table showing the drafts in each pass. There has been a trifle more work on the head than on the flange in each case, because the flange cools quicker than the head and is therefore harder to reduce. If this fact were disregarded, the piece would have a tendency to deliver crooked.

Pass No. 10, called the "leader" is constructed to bring the piece as near to the shape and size of the finished material as possible. As designed, it requires a reduc-

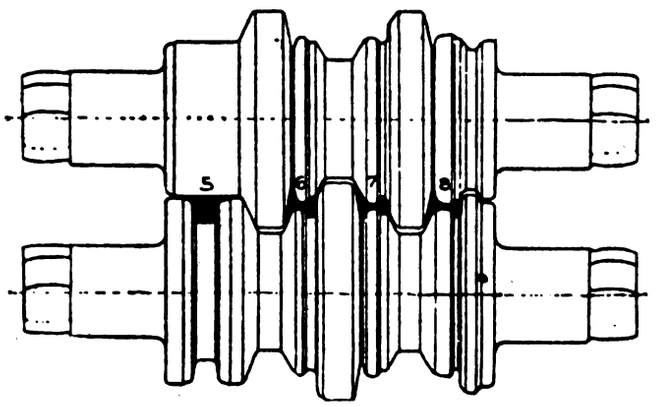

Fig. 2.—Intermediate roughing rolls.

tion of only 3.59 per cent to make the finished rail. The height is made 1/16-in. less than the finisher to allow for spread. The closed flange is made the same length as the finisher, as it will not lengthen with such slight draft. The open flange is made ⅛-in. longer than the closed flange in the finisher, so that the same angle makes it thin enough to go to the bottom of the closed flange in No. 11 pass, and the additional length will insure the work being done on it, filling the corners and giving the desired width. The fillets on head and flange are made 1/32-in. greater than on finisher, to give a little work at these points in working out the ¼-in. fillets to hold the piece in place. The head is longer on both sides than No. 11 pass to give enough to fill out the splice bar. There is only 1/64-in. up and down work required on the web but this is enough to give the brand, while more work would tend to pull the metal away from the flange.

Edging Pass Work Varies.

In all passes of this construction, which are called edging passes, there should be more up and down work on the flange than on the head, and more on the head than on the web.

This is made necessary because the diameter of the rolls are different at each point and therefore have different peripheral speeds, which causes the metal to flow differently, pulling away from the slower moving parts of the rolls more than from the faster traveling parts. Pass No. 9, called the second edger, is very similiar in design to No. 10, but the work is 19.72 per cent instead of only 3.59 per cent. The height is 3/32-in. less than No. 10, to allow for spread, which will be greater here than in No. 10 because of the greater reduction in the web than the open flange in No. 10.

The open flange is made ⅜-in. longer from the edge of the web than the closed flange in No. 10 to give the closed flange from the preceding pass a chance to lengthen, which will make it thin enough to go into the closed flange of No. 10. The fillets are made larger than in the leader to give work at these four points, which steadies the piece in the pass. The head is made wider, 1/16-in. on the closed side and ⅛-in. on the open, to allow enough up and down work to force the steel to fill the head, which it would not do otherwise, because it is necessary to carry a great deal more stock in the head from No. 8 than is needed. This makes the head thick and keeps it from entering the groove readily. The web is made thin enough to give the portion of work, necessary to keep the percentage as near that required as possible, but on account of the large diameter of the rolls at this point the up and down work should not be great.

No. 8, called the first edger, is a very important pass, for, unless it is designed so that it will fill properly, the following passes will not work as designed. The height is made 3/32 inch less than No. 9, to allow for spread. The closed flange is made 1/32 inch shorter than the long flange of No. 9 from the edge of the web to allow for lengthening a trifle. The open flange is made 9/16-in. longer from the side of the web and the angle of the flange is made a little greater than No. 9, so that the flange will be thin enough to go home in the closed flange of the second edger. If successful in this, there is not much danger of a narrow flange, for most causes of narrow flanges come from the failure to bottom in the closed flane in this and the following passes. There is little more than ½-in. up and down work on the head, which will keep the metal from pulling away from the head, which it is very likely to do, as there is much heavy work on the web. For this same reason the fillets on head and flange are made larger. The corners of the head are well rounded to keep the steel from overfilling in the open roll, which would cause a fin. In this, as in all the edginig passes the flange is turned a trifle from the line perpendicular to the center line, flaring out from the closed roll flange: this is done so that the piece will deliver freely from

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the pass without wearing the rolls excessively.

In the second edger and finisher, where it is more important that the rolls hold their shape, the head is also turned from the perpendicular. The rolls wear much less when this is done and because of the taper, they can be brought to the correct height with less dressing when they do become worn. No. 7, is called the finishing dummy. It is the first of the finishing passes and is called a dummy pass because it does not assist much in shaping the rail nor does it reduce the area except by a small percentage. This pass is used to squab the piece down to the proper height to permit the spread in the following passes. Its most important function, however, is to make the flange thin. The longer flange coming from No. 6 is 11/16-in. thick at the point, while the same flange is only ¼-in. coming from the dummy; so it is seen that the flange is made much thinner and consequently longer in this pass.

It is to be noted that one flange is longer and thinner than the other, the longer flange is the one that goes into the closed roll of No. 8 and must bottom in that pass or loss of width of flange would result, which

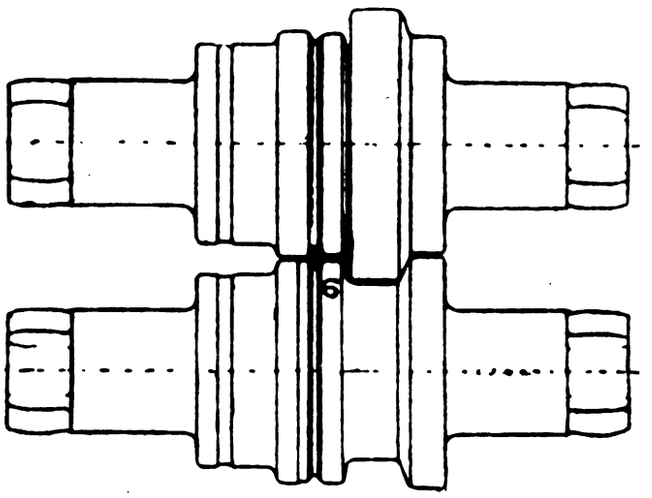

Fig. 3.—Finishing pass.

defect would carry right through the balance of the finishing passes.

The width of the head is made just enough greater than No. 8 to give the amount of up and down work desired and the corners are well rounded to prevent over-filling in the succeeding passes, which would cause a fin. The top of this pass is made V-shaped to help force the metal out of the flange. As the rolls wear, the top roll must be lowered or the flanges will become too thick to enter the closed roll in No. 8. Frequently the top roll of the dummy is made a chill roll, so that the wear will not be so great. This then completes the design of the finishing passes.

The light and heavy sections cannot be made from the same roughing passes as there is such a difference in the amount of stock required to make the different sections Sections from 50 to 70 pounds are made with the same roughing passes and sections from 70 to 90 pounds are made on another set of passes. For all sections, the first four roughing passes remain the same, the change from the light to the heavy sections requiring a change in the last two roughing passes. While the design of the roughing passes is not so particular as that of the finishing passes, there are a number of precautions to be observed or the passes will not work properly. The biggest difficulty in these passes is to get the reduction and shape the rail without making the flange too narrow.

In all the finishing passes the work that is done in shaping the rail, tends to make the flange narrow, so that it is necessary to have the flange coming from the roughing passes wider than required in the finished rail. To accomplish this, different style passes are alternated in such a manner that the edging passes, which do so much toward shaping the rail, and thereby making the flange narrow, are followed by squabbing or dummy passes that do little or nothing toward shaping the rail but keep the height down and roll out the flange, making it thinner.

Table showing area and reduction of rail in various passes.

Pass	Area, square inches.	Reduction, Per Cent	Head, Area.	Per Cent	Web, Area.	Per Cent	Flange. Area.	Per Cent
1	46.32	22.8	5.14	43.34	2.48	20.91	4.24	35.75
2	36.63	20.92						
3	29.58	16.05	3.75	41.52	1.93	21.37	3.55	37.10
4	23.23	21.5						
5	19.85	14.5	3.02	41.65	1.55	21.38	3.68	36.96
6	16.52	16.7						
5-H ...	21.87	5.84	2.92	41.77	1.50	21.46	2.53	36.77
6-H ...	18.14	17.05						
7	15.67	5.2						
8	11.86	23.68						
9	9.03	23.86						
10	7.25	19.72						
11	6.99	3.59						

Passes No. 1 and 2 are box passes and in both the reduction is heavy. These passes make the piece narrower in the head and shorter in height. The up and down work necessary to reduce the height causes the piece to spread and begin to form the flange, which effect is exaggerated by putting a swell on the bottom of the passes; this also prevents the piece from over filling in the succeeding edging pass, which would cause a seam.

No. 3 is called an edging pass because the piece entered on edge, that is, turned through 90 degrees from the position it was going through Nos. 1 and 2. In this pass the piece begins to get the shape of the rail, considerable more work being done on the web than on the head and flange. The part of the rolls that reduce the web is made quite sharp; that is, 9/16-in. radius rather than presenting a wide surface at that point,

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which would tend to pull the metal away from the flange more than would the narrow tongue. The swell made in the top and bottom of No. 2 prevents the piece from overfilling the pass when it spreads.

No. 4 is a dummy pass and does nothing toward shaping the rail but makes the piece lower and the flange wider. The height is squabbed down to 4 3/16 in this pass and the top and bottom are made concave again to allow the piece to spread in the two following edging passes without overfilling.

In order to assure stock enough for the heavier sections, passes 5-H and 6-H are laid out for sections from 70 to 90 pounds as well as passes Nos. 5-L and6-L for sections under 70 pounds. By reference to the table below showing percentage of reduction the difference in the draft for tight and heavy section is seen. Both Nos. 5 and 6 are edging passes and in both considerable work is done on the web of the piece. As in No. 3, effort is made to get the reduction and shape the piece without pulling the metal away from the flange any more than is necessary. The flange and head are tapered off in both rolls in these passes so that the piece is free to deliver itself without undue wear of the rolls.

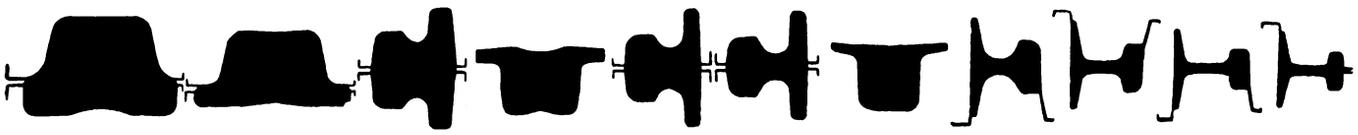

Fig. 4.—Railroad passes used by the Carnegie Steel Company, the lines show joints with rolls.

No. 6 is the first pass in which one side of the flange is made longer than the other. This is done so that the piece as it comes out of No. 7 will have one flange longer and thinner than the other and will therefore go home in the flange of the closed roll in the edging or finishing passes.

The table on page 369 shows the area reduction in the different passes and the distribution of the area in the finishing passes.

In turning the rolls, the pitch diameter of one roll is made about ⅛-in. greater than that of its mate so that the piece will always deliver one way; that is, away from the largest roll, which makes it possible to do away with one guide on the delivery side of the rolls. It is an advantage to have the piece deliver away from the closed roll in the finishing passes, so that the grooved roll shall have the greatest pitch diameter.

It is customary on a 24-in. mill to make the pitch diameter of the grooved roll ⅛-in. greater than that of the tongue roll. The parting between the finishing roll is ⅜-in. and between the roughing rolls ½-in. and the parting line, where collars and grooves of a pair of rolls are in contact, is made at an angle from 10 to 15 degrees, so that when the rolls are re-dressed, the lock can be re-established by turning off a little at these points. This is an important point and it allows a pair of rolls to be re-dressed more times than if the parting were made nearer a straight line. The rolls have to be taken out of the mill frequently to be redressed, sometimes because they have worn so that the rail becomes too high but more generally because they become too rough and do not make a smooth rail.

At the Ohio works the finishing is in sand rolls, which will make about 3,100 tons in two passes without re-dressing. At Braddock, Pa., before the cold rolling process was adopted, 3,000 tons were finished on one pass to a dressing. It will be apppreciated that the temperature at which the piece goes through the finishing pass has great bearing on the life of the rolls.

At South Chicago, there is a chilled pass finishing as much as 5,187 tons in one pass to 1 dressing. Too little water on the rolls fails to keep them cool and heat checks appear, which make the rolls rough. Too much water causes water cutting. The latter is harder on the rolls than the cutting done by steel. The water should run on the rolls with only about a 6-in. head and the quantity should be limited to the amount required to keep the rolls cool enough to prevent heat cracks.

Some time ago the Carnegie Steel Company, installed at its Edgar Thomson plant a cooling bed before the finishing pass, on which the rails are allowed to remain for a short time before going into the rolls. The rails are held in this bed about one minute and six seconds, during which time their temperature drops from 1,760 Fahr. to 1,580 deg., which gives the steel a close-grained structure and a nice finish. This cold rolling is much harder on the rolls than the old practice of finishing at a higher temperature.

In contrast to this cold rolling, now being employed in the above mentioned plant, is the re-heating of a certain percentage of blooms in the South Chicago mill. (rail mill). This re-heating is done to make the steel roll easier and is a very effective means of reducing the percentage of seconds. But because of the rails being finished at this high temperature it is said, the steel has not as fine a structure as when the blooms are not re-heated, but are finished with the heat given the ingots in the soaking pits, as at the Ohio works.

The standard length of rails was 30 feet until recently, but now 38 feet is the standard, which requires a less number of joints per mile, without making the rails much more difficult to handle or transport, as nearly all cars are 34 feet or more inside the bed. The rails cut to length at the Ohio works by four hot saws 42 inches in diameter, which revolve 1,400 revolutions per minute, are set the proper distance apart and are so operated that all four come down on the rail at once. In order that the rail when cool, shall have the proper length, the hot rail is sawed to a length to allow for the

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contraction due to the fall in the temperature.

It will be seen that this length will vary for different mills and will depend on the temperature of the rail when sawed. Even in the same mill different weight sections are sawed to different lengths, because the heavier sections are hotter when sawed than the lighter sections. Below is a table showing the lengths the different sections are sawed at South Chicago and Ohio to make rails that will be 30 feet long when cold.

It is noticed that the rails are sawed shorter at Ohio than at South Chicago, bearing out the statement made above, that the rails finished at the lower temperature at the first named point. At Braddock, Pa., they are sawed considerably shorter than at either of the above mills because of the cold rolling process. It is very desirable to have the saw mandrel bearings adjustable, so that when they become worn, which they do rapidly on account of the high speed at which the saw revolves, they can be moved until the saw is plumb again.

Section. Pounds.	South Chicago. Ft. and In.		Ohio Works. Ft. and In.	
100	30	6 ½	30	5 7/8
15	30	6 7/16	30	5 13/16
90	30	6 3/8	30	5 3/4
85	30	6 5/16	30	5 11/16
80	30	6 1/4	30	5 5/8
75	30	6 3/16	30	5 9/16
70	30	6 1/16	30	5 9/16
65	30	5 7/8	30	5 7/16
60	30	5 3/4	30	5 3/4
55	30	5 5/8	30	5 5/16
50	30	5 ½	30	5 1/4

Production of Low Carbon Electric Steel

Repairing furnace lining—Care in use of roll scale and lime—Formation of reducing slag—Advantage of recarburizing over melting down to desired carbon content.

By A. S. HELLSTROM.

At the present time one of the greatest fields for the electric furnace is in the manufacture of small castings. When the electric furnace was first put in operation in this country it became a great point of consideration as to whether it would ever be able to compete with the open hearth or Bessemer converter in the cost of production, but now with the present low cost of electric power and the high cost of pig iron, the electric furnace has placed itself on an equal if not better basis with either of the older methods. Day by day the electric furnace is gaining favor with the small castings manufacturers on account of the supreme quality of the steel, the rapidity at which the heats can be produced and the exceedingly high temperature at which the metal can be brought to before tapping.

Furnace Bottom.

The furnace bottom for the electric furnace can be either acid or basic, but it has been found from practice that the basic bottom is most satisfactory. By the use of the basic bottom the phosphorus and sulphur can be extracted, while with the acid bottom furnace, this process cannot be carried out. The basic bottom is made up with magnesite mixed with about 20 per cent of basic slag and bonded with tar. A bottom of this nature properly burned in, a layer at a time, should remain an indefinite length of time. When bricking up the furnace, that is after 110 to 150 heats having been taken out, only a portion of the banks need to be removed. Some furnaces have been known to put out over 150 heats before relining, but from practice the writer has found it more satisfactory to shut down and brick up before the walls burn through or fall out, of their own accord.

One great advantage of the electric furnace is the nature of the charge which it reclaims. The furnace is first charged with 5,000 to 7,000 pounds of turnings —considering a six-ton furnace. After this charge is melted down the second charge of scrap consisting of heads, gates, spills and scrap castings are added, to make up a full heat. When the entire heat is melted down and no special analysis is required, a fracture test for carbon is made and the heat slagged off. The heat is next recarborized to the desired point, the ferro manganese and ferro silicon additions made, and the carbide slag placed on the metal. After the heat has been brought to the proper temperature and the steel is not wild, it can be tapped with perfect safety.

Should a special phosphorus and sulphur analysis be required, a process of refining must be carried out. About ninety pounds of lime and a little roll scale are then charged with the scrap. Care should be taken in the amount of roll scale added if the turnings charged are covered with rust. Another point should be considered, and that is the use of a good grade of calcium lime. Magnesium lime will not prove satisfactory and it has a very high melting point. After the entire heat is melted down and the oxidizing process carried out, the slag is made fluid by the addition of spar, and the heat is slagged off. The carbide slag is then placed on with lime, coke dust, spar and sand and the heat is carried out as in the preceding

(Continued on page 392)

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PRODUCTION TOPICS

DATA ON ROPE DRIVE FOR ROLLING MILLS.

At a meeting of the Engineers Society of Western Pennsylvania, Prof. Trinks of the Carnegie Institute of Technology, presented some data on rolling drives, in connection with a discussion by him of a paper read before the society on cotton rope for power transmission, by J. Melville Alison. Length of life of rope, under varying conditions, was found from inquiries at almost all rolling mills using rope drives. The mass of data thus obtained was carefully sifted and

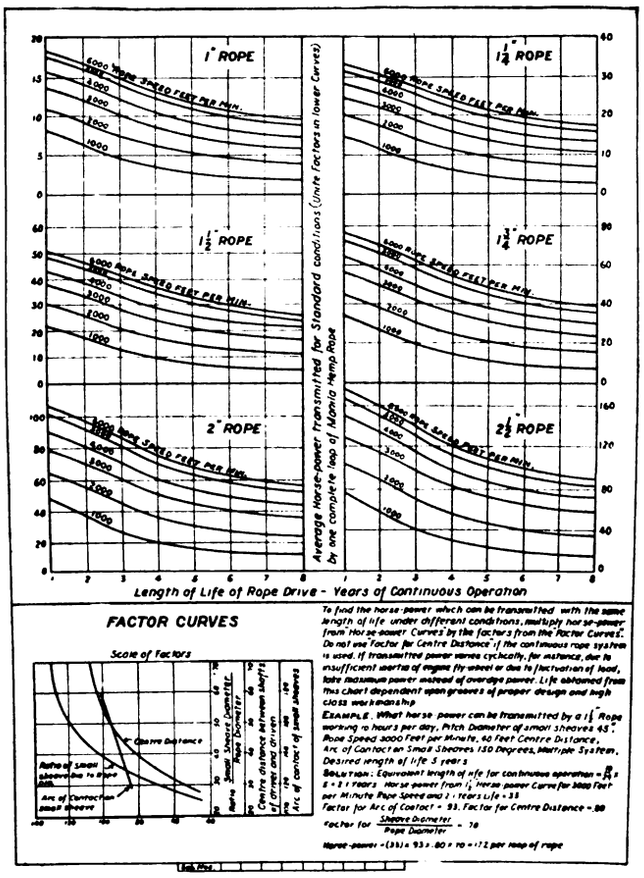


Chart showing length of life of manila rope plotted against average horsepower transmitted.

plotted. Kinks in the curves were smoothed out, because it was evident that in some cases the short life of the rope was due to improper finishing of the rope sheaves, or to lack of alignment. The chart is particularly useful in determining the smallest diameter of rope sheave which can be succesfully used . Evidentally, smaller sheaves mean lower first cost, but greater cost of renewals and more frequent shutting down for repairs. The chart assists in finding where the sum of the two costs is a minimum. The chart refers to manila ropes.

TORQUE AND WORK OF ACCELERATION.

By Philip Hoffman.

It often occurs that a designer must consider the effects of inertia of the rotating parts of the machine he has in view, that is, the work time, or torque required to accelerate the rotating weights of the different parts. The calculations required for this are expressed none too clearly either in the text books or the different hand-books.

The following was written with the aim of showing a few convenient equations for use in calculating the effects of accelerated rotating parts, either as a part of one shaft or as weights on a series of geared shafts. The formulae are numbered and will be useful in the design of mill and mill table drives, brakes, fly-wheels, etc. and are presented in such a form as to require no difficult or very tedious calculations.

The first effect to be considered is the torque exerted on or by the accelerated rotating weights. Inspection of equation (1) will show that the torque varies inversely as the time or period of acceleration; that is, the greater the torque the smaller the time required to attain the required speed. We may first say that in rotating masses the point of application of the inertia force producing or opposing the acceleration is at a distance from the axis equal to the radius of gyration which we will designate as r.

Force equals weight times acceleration divided by the acceleration due to gravity. $F = Wa/g$

$$\text{acceleration} = a = (V' - V'')/t$$

V′ & V″ are velocities at a distance r from the axis where

$$V' = 2\pi rN' \;\&\; V'' = 2\pi rN''$$

N′ & N″ being revolutions per second at the beginning and at the end of the accelerating period t.

Therefore we may write the expression for force as

$$F = W\,(V' - V'')/gt = 2\pi rW\,(N' - N'')/gt$$

But as torque is force times the lever arm we have for equation

$$(1)\quad \text{Torque} = T = 2\pi Wr^2\,(N' - N'')/gt$$

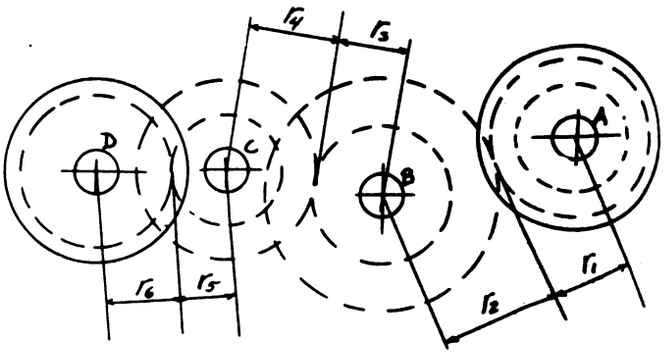
As the moment of inertia of a solid equals the weight times the radius of gyration squared, equation (1) may be expressed

$$(2)\quad T = 2\pi I\,(N' - N'')/gt$$

where

r = radius of gyration
W = weight of rotating body
N′ & N″ as before stated
t = time required to accelerate the body from speed N′ to N″

Supposing however we have a gear train with weights on each shaft as shown in the figure, and we wish to find the torque exerted on shaft "A". Then the sum of all the



torques exerted on shaft "A" is the sum of each torque times its gear ratio to shaft "A", and may be written as:

$$\Sigma T = T_A + T_B\frac{r_1}{r_2} + T_C\frac{r_1 r_3}{r_2 r_4} + T_D\frac{r_1 r_3 r_5}{r_2 r_4 r_6}$$

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where TA, TB, Tc etc. are the torques of each shaft as expressed in equation (2). Substituting the values of equation (2) we have:

$$\Sigma T = \frac{2\pi}{g t}\left[I_A(N'_A - N''_A) + I_B(N'_B - N''_B)\frac{r_1}{r_2} + I_C(N'_C - N''_C)\frac{r_1 r_3}{r_2 r_4} + \text{etc}\right]$$

or expressing the speed of each shaft in terms of the speed of shaft A we have the final value for torque or
(3)

$$T = \frac{2\pi}{g t}(N' - N'')\left[I_A + I_B\left(\frac{r_1}{r_2}\right)^2 + I_C\left(\frac{r_1 r_3}{r_2 r_4}\right)^2 + I_D\left(\frac{r_1 r_3 r_5}{r_2 r_4 r_6}\right)^2\right]$$

Where IA, IB, Ic, ID are moments of inertia of the different shafts.

In the above and the following discussion friction has not been considered, in any case however it acts against a positive or with a negative acceleration.

Having the torque it is an easy matter to derive the ENERGY or WORK done. If a body rotating with a constant acceleration the energy or work equals

$$E = 2\pi TNt$$

where

N = average speed = ½ (N′ — N″)
t = time under consideration.

or

$$E = \pi TtN' - \pi TtN''$$

Replacing T with its value in equation (2) (making N″ = O as we must take the difference of the total energies) we have:

(5) $E = 2\pi^2 I\ (N'^2 - N''^2)/g$

And for a train of gears using equation (3) instead of (2) we have:
(6)

$$E = \frac{2\pi^2(N'^2 - N''^2)}{g}\left[I_A + I_B\left(\frac{r_1}{r_2}\right)^2 + I_C\left(\frac{r_1 r_3}{r_2 r_4}\right)^2 + I_D\left(\frac{r_1 r_3 r_5}{r_2 r_4 r_6}\right)^2\right]$$

(7) Horespower = E/550t

One of our readers disagrees in part with the development of the formulae and adds the following,—

In glancing over the article by Mr. Hoffman on the above subject I observed a few errors which should be corrected.

The general formula for force is customarily stated as the product of the mass of the body whose motion is being accelerated, by the acceleration. Thus

Force = F Ma W/g a pounds.

This it seems to me is the most familiar way to most of us in which to state the above formula.

With the assistance of this force equation Mr. Hoffman derives the torque equation,

Torque = T = $2\pi Wr^2$ (N′ — N″)/gt ft. pounds

where r is the radius of gyration in feet and N′, N″ are the rev. per sec. at the end and beginning respectively of the acceleration period.

Since the moment of inertia of a solid cylinder is equal to the mass (not the weight) times the radius of gyration squared then the torque equation becomes

$T = 2\pi I\ (N' - N'')/t$ ft. pounds.

If instead of revolutions per second, N′ and N″ equalled the R.P.M. the torque equation will be given as

$T = \pi I\ (N' - N'')/30t$ ft. pounds

Hence the total torque equation can now be stated as

$$T = \frac{\pi}{30t}(N' - N'')\left[I_A + I_B\left(\frac{r_1}{r_2}\right)^2 + I_C\left(\frac{r_1 r_3}{r_2 r_4}\right)^2 + I_D\left(\frac{r_1 r_3 r_5}{r_2 r_4 r_6}\right)^2\right] \text{ ft. pounds}$$

where r_1, r_2, r_3 etc are in feet.

In using this last equation in the design of a system such as Mr. Hoffman shows in Fig. 1 of his article there should be given some thought as to the possible effect of gear tooth inaccuracies upon the nature of the shaft accelerations. In the derivation of the above expression for torque it has been assumed that the rate of velocity change was constant.

In accordance with the above changes the energy equation is

$$E = \frac{\pi^2(N'^2 - N''^2)}{30}\left[I_A + I_B\left(\frac{r_1}{r_2}\right)^2 + I_C\left(\frac{r_1 r_3}{r_2 r_4}\right)^2 + I_D\left(\frac{r_1 r_3 r_5}{r_2 r_4 r_6}\right)^2\right] \text{ ft pounds}$$

A. H. B.

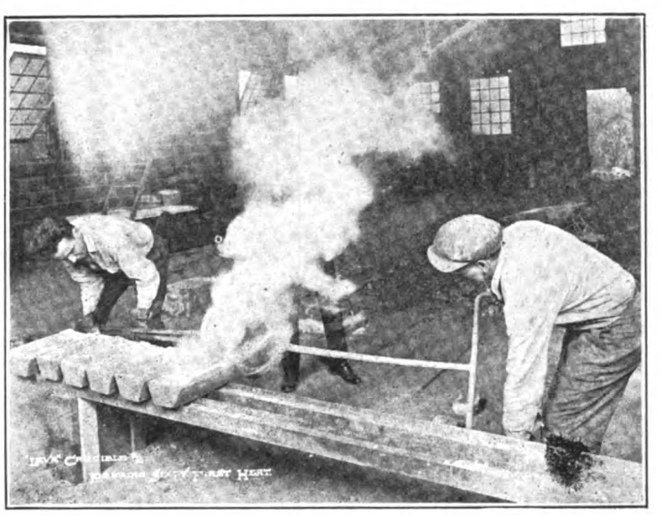
NEW LAVA CRUCIBLE STANDS 70 HEATS.

The Lava Crucible Company, a Pittsburgh firm, has just completed a public demonstration of its new product, the "Lava" crucible, in their plant at Zelienople.

The service rendered by one crucible extended through 70 heats. When the crucible was taken out of service it would still have permitted further usage.

Long tests were made in melting brass. One of the companies Commercial size No. 60 crucibles weighing 35 pounds before use, and 31 pounds after use was charged with an average of 89 pounds, and stood up to 70 heats.

Such service has never been heard of before even when German clays were available and Ceylon graphite could be purchased in the United States in quantities. The inability of crucible manufacturers to secure these two ingredients has had a material effect upon the finished crucible of to-day,



Lava crucible pouring sixty-first heat.

and the difficulties have not been relieved by the greatest demand for crucibles this country has even known, due to the manufacture of ammunition and other war supplies requiring great quantities of steel and brass products.

The crucible formerly manufactured from the superior clays and graphite stood from 12 to 15.

Mr. J. H. L. DeBats, the inventor of the "Lava" crucible, has spent several years in the development of this product. He says that, besides the increased service, the crucible which he has developed will not require the extensive drying and preliminary heat treatment at present necessary.

The directors and officers are all Pittsburgh men, most of whom are well known. The directors are M. E. Moffett, P L. Berkey, E. J. Thompson, M. W. Ray, A. W. Weiland, Samuel L. Catanzaro and Mr. DeBats. The officers are President, M. E. Moffett; vice president, M. W. Ray; secretary and treasurer, P. L. Berkey.

The company will proceed with the manufacture of crucibles as quickly as they can secure proper plant site and additional equipment The company has completed plans for increasing the capacity of its plants to 2,000 crucibles per week.

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INDUSTRIAL SAFETY

SAFE PRACTICE IN USE OF CHAINS AND ROPES.

Many accidents causing injury not only to life and limb, but also to the materials handled, are constantly occurring on account of disregard for the proper use of methods of slinging and hooking. For the promotion of safe practices, everyone should be familiar with the fundamentals govering the application of these important mechanical devices and principles.

Low carbon open hearth steel and wrought iron are both used by reliable manufacturers for hoisting chains. Some engineers favor the use of the best quality of iron, such as Norway or Swedish, claiming it will lend itself to a better weld; has a greater ductility, which allows it to yield under an over-load rather than snap, and is less liable to injury than steel if worked at improper temperatures. A suitable quality of iron should be tough and produce a silky, fibrous facture; it should be uniform throughout, free from laminations caused by layers of slag between the fibres, and be free from an excess of phosphorous and sulphur, which would cause cold and red shortness.

Specifications.

Prepare a rigid set of specifications to govern the purchase of all chains, and insist that the purchasing department buy on quality and reputation of manufacturer, rather than price. Insist on material passing physical tests in accordance with the standards adopted by the American Society for Testing Materials. Links should have a smooth, workmanlike finish, and be free from cracks and scars of such a nature as to cause a material reduction in the net cross-sectional area. Links should be formed by the three-heat process; that is, first heat bending the stock bar to "U" shape; second heat, scarfing the ends, and third heat, driving home the weld. Insist on hand made links with long lap welds, so finished as not to cause a bulging or any material increase of the section at the weld. Machine-made or so-called coil-wound links are not acceptable, because such severe initial internal stresses are set up in the stock bar, due to being bent around so short a radius while cold. Such links also have the additional disadvantage of a short-lap weld. The major and minor axis of a link should be as small as possible, as it not only gives a greater flexibility to the chain put also keeps the bending stresses in the link down to a minimum.

SAFE LOADS FOR ROPES AND CHAINS
(IN POUNDS)

Based on Table Prepared by National Founders' Association

CAUTION When handling molten metal, wire ropes and chains should be 25% stronger than indicated in table

	DIA. OR CIR.	WHEN USED STRAIGHT	WHEN USED AT 60° ANGLE	WHEN USED AT 45° ANGLE	WHEN USED AT 30° ANGLE
NOTE—The safe loads in table are for each SINGLE rope or chain. When used double or in other multiples the loads may be increased proportionately.					
PLOW STEEL WIRE ROPE (6 strands of 19 or 37 wires) If crucible steel rope is used reduce loads one-fifth	½	1,500	1,275	1,050	750
	⅝	2,400	2,050	1,700	1,200
	¾	4,000	3,400	2,800	2,000
	⅞	6,000	5,100	4,200	3,000
	1	8,000	6,800	5,600	4,000
	1⅛	10,000	8,500	7,000	5,000
	1¼	13,000	11,000	9,000	6,500
	1⅜	16,000	13,500	11,000	8,000
	1½	19,000	16,000	13,000	9,500
	1¾	22,000	19,000	16,000	11,000
	DIA. OF IRON				
CRANE CHAIN (Best Grade of Wrought Iron, Hand-Made, Tested, Short Link Chain) The material having an ultimate strength = 48000 × □"	½	300			
	⅝	675	.....	.....	.....
	¾	1,200	.....	.....	.....
	⅞	1,870	.....	.....	.....
	1	2,700	.....	.....	.....
	1⅛	3,680	.....	.....	.....
	1¼	4,800	.....	.....	.....
	1⅜	6,050	.....	.....	.....
	1½	7,500	.....	.....	.....
	1⅝	9,100	.....	.....	.....
MANILA ROPE (Best Long Fibre Grade)	DIA.	CIR.			
	1/16	1	120	100	85	60
	¼	1½	250	210	175	125
	⅜	2	360	300	250	180
	½	2½	520	440	360	260
	⅝	2¾	620	520	420	300
	1	3	750	625	525	375
	1⅛	3½	1,000	850	700	500
	1¼	3¾	1,200	1,025	850	600
	1½	4½	1,600	1,350	1,100	800
	1¾	5½	2,100	1,800	1,500	1,050
	2	6	2,800	2,400	2,000	1,400
	2½	7½	4,000	3,400	2,800	2,000
	3	9	6,000	5,100	4,200	3,000

Table of safe loads showing the desirability of putting the tension in a sling as nearly straight as possible.

Safe Loads.

Prepare a table of safe loads, based upon the maximum permissible stress of the material that is used in the manufacture of the link The following formula is recommended as amply safe, and, although it gives loads that are much smaller than those recommended by well known manufacturers, the users of such loads can feel reasonably assured that the material has not been stressed beyond the elastic limit:

Formula *

$$P = 0.4\ fd^2$$

Where P = the safe load, and
f = the permissible fibre stress of the material in the link, and
d = the diameter of the stock used in the links

Generally the strength of a chain link is calculated from the direct internal stresses produced in the cross section of the link by the loading and neglecting the bending stresses which are undoubtedly present. The formula cited above takes into consideration the stresses produced by the bending moment which accounts for the lower value of the safe loads.

Insisting on proper loading of chains is a most important precaution, as overloading will cause fatigue or so-called crystallization by reducing the ductility or hardening the material, and annealing after such a state is reached does not restore the ductility completely, although it does remedy the condition.

Inspection during service and after repairs.

Inspection should be made at least once a week, and oftener if the chain is in constant use, by a competent and experienced man to detect any appreciable reduction of section in the links due to wear or abrasion, any deformation of the links due to overloading, and visible flaws in the welds. Chains which have been overloaded to such a point as to cause fatigue, can be detected by a characteristic ring, which is yielded when struck a sharp blow with a hammer. Further proof of such condition can be obtained by placing the link edgewise on an anvil and striking it several sharp blows with a sledge. If it is fatigued it will fracture sharply with a decided crystalline appearance. In case a chain is found to contain a link of such a nature the safe thing to do is to discard the entire chain for ali overhead lifting purposes where life is in danger. The connecting link should be designed to resist the same load as the chain.

* (Note—This formula developed by Experimental Station, University of Illinoise.)

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NEWS OF THE PLANTS

The East Jersey Pipe Corporation, Patterson, N. J., East Thirty-sixth street, is remodeling and improving its plant for the manufacture of shells. Considerable new machinery is being installed. It is planned to commence active operation early in August.

The Bethlehem Steel Company, Steelton, Pa., has completed the construction of a new furnace at its local works, with capacity of 200 tons. The Bird Coleman furnace No. 1 at the Lebanon works has been placed in operation following relining and improvements.

The National Casting Company, Marietta, Pa., recently organized to take over the plant of the Marietta Manufacturing Company, is making rapid progress in remodeling and extensions. The company is planning to operate the works at the earliest possible date for the production of iron and steel castings. J. H. Foreman is head.

The Crown Smelting Company, Chester, Pa., Concord avenue, has commenced the construction of a new two-story addition.

The American Sheet & Tin Plate Company, New Castle, Pa., has commenced the operation of the first of its new double hot mills for the production of tin. The company is making rapid progress in the construction of additional mills to comprise a total of ten new units for the manufacture of tin and terne plate.

Fire on July 11 destroyed the 18-inch mill, and sections of the rigging and electrical shops of the Willmington Steel Company, Wilmington, Del., Third street, with loss estimated at $150,000. The company is a subsidiary of the Midvale Steel Company, Philadelphia, It is said that the plant will be immediately rebuilt.

The Bethlehem Steel Company, South Bethlehem, Pa., has awarded a contract for the construction of a one-story, brick and steel addition, 60x120 ft., at its Sparrows Point, Md., plant to be used as a copper shop. The Singer-Pentz Company, Equitable Building, Baltimore, has the contract for erection.

The Wheeling Mold & Foundry Company, Wheeling, W. Va., specializing in the production of iron and steel castings, will operate its plant at full capacity during the coming months for the production of battleship armament. It is said that the company has secured a contract to insure maximum production for about 24 months ahead.

The Phillips Sheet & Tin Plate Company, Wierton, W. Va., specializing in the manufacture of cold rolled stripped steel and tin plate, is planning the construction of additions to increase the present capacity.

The Edge Moor Iron Works, Edge Moor, Del., will build a two-story steel and concrete addition to its plant, about 32 x 80 ft.

The Universal Smelting & Refining Company, Newark, N J., will build a one-story, brick and steel plant, 110 x 450 ft. at 154 St. Charles street, to cost about $154,000. The plant will be used for the production of tin, lead, etc. Plans for erection have been filed.

The Raritan Copper Works, Elm street, Perth Amboy, N. J., is making rapid progress with the erection of an addition to its plant to be used for increased capacity. The structure will cost about $40,000.

The Vance County Iron Works, Henderson, N. C., is planning for the construction of an addition to its plant to cost about $10,000.

The Worth Brothers Steel Company, Claymont, Del., has taken bids for the erection of a new two-story brick and steel building, 50 x 185 ft., at its local steel works now in course of completion.

Fire recently destroyed a portion of the open-hearth casting plant of the Penn-Seaboard Steel Corporation, New Castle, Del., with loss estimated at about $25,000.

The Chrisman Foundry Company, Westover, W. Va., has been incorporated with a capital of $100,000 to operate a local plant. A. H. McBee, Frank Fox and E. F. Beall, all of Morgantown, W. Va., are the incorporators.

The Wickes Boiler Company, Midvale, N. J., 90 West street, New York, is negotiating with the owners of the Midvale iron properties for the acquisition of the land for operation. It is said that the company plans to work the property at full capacity.

The Newport Iron Company, Harrisburg, Pa., has completed the remodeling and improvement of the Lochiel iron furnaces, South Cameron street, and will operate the plant at full capacity. The property was recently acquired from the Bethlehem Steel Company. The works will give employment to about 100 hands. E. E. Marshall is president.

The Sweetser & Bainbridge Metal Alloy Company, Albany, N. Y., has been incorporated with a capital of $10,000 to manufacture metal alloys and metallic specialties. S. P. Sweetser, E F. Bainbridge and H. G. Batcheller, Albany, are the incorporators.

The Bureau of Yards and Docks, Philadelphia, Pa., United States Government, has taken bids for the construction of three new shell houses at the Fort Mifflin works, each one-story, about 50 x 200 ft. With new magazine buildings, the extensions will cost $300,000.

The Charleston Alloy Steel Company, Belle, W. Va., has been incorporated with a capital of $500,000 to operate a local plant. J. M. Payne, Berkeley Minor Jr., and G. P. Brennan, all of Charleston, are the incorporators.

The Brettler Sheet Metal Works, New York, has been incorporated with a capital of $10,000 to manufacture iron floor plates. B. Brettler, the principal incorporator, operates a metal working plant at 227 East 47th street. A. and M Brettler are the other incorporators.

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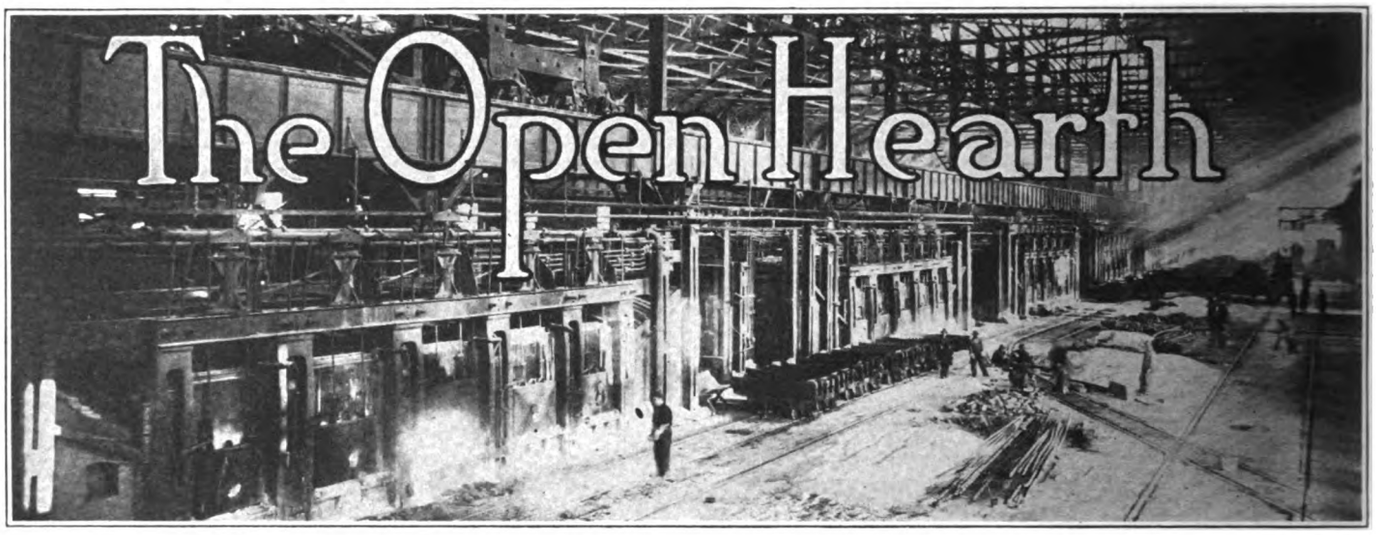

R. A. Field has resigned as night superintendent of the Broken Hill Proprietory Steel Works of New Castle, Australia, to accept the position of superintendent of blast furnaces of the Oriskany Ore Iron Company, Lynchburg, Virginia.

V V

O. B. Shitts has resumed charge of the Marietta blast furnace plant for E. J. Lavino and Company. He was formerly assistant superintendent of the Illinois Steel Company at Joliet, Ill.

V V

C. H. Hobbs, former assistant to A. P. Van Schaick, district sales manager of the Lackawanna Steel Company at Chicago, has been made district sales manager of his company at Detroit, succeeding Jay C. McLauchlan, resigned. Mr. Hobbs has been associated with the Lackawanna Steel Company about nine years.

V V

Charles S. Clark, formerly of the Pennsylvania Steel Company, Boston, has been elected first vice president and general manager of the Laconia Car Company, and will make his headquarters at Laconia, N. Y., where the business of the company will be conducted hereafter. Mr. Clark has been well known to the New England railroad, electric railway and steel business for many years.

V V

George T. Williams has resigned his position as operating engineer with H. Koppers Company, to accept the position of general foreman at the by-product coke plant of the Brier Hill Steel Company at Youngstown. He has been connected with the operation of the plants of the LeClede Gas Light Company, St. Louis Mo.—the Lehigh Coke Company, So. Bethlehem, Pa., LaBelle Iron and Steel Company, Steubenville, Ohio and the Inland Steel Company, Indiana Harbor, Ind.

V V

Kall & Company of Tokyo, the Japanpse agents for the American Steel Export Company, have added Mr. B. Orum Andresen to their engineering staff.

V V

Julian D. Page has left the Mark Manufacturing Company to take up a position of chief draftsman with the Tata Iron and Steel Company.

V V

E. J. Parker, manager of the Morgan Engineering Company, has joined the staff of the Vulcan Steel Products Company, 120 Broadway, New York, as sales manager of the machinery and tool department.

Charles M. Schwab and other officials of the Bethlehem Steel Company were in Baltimore July 9 and witnessed the launching of the steamer Cubore, which was built at the Sparrows Point, Md., plant of the company for the Ore Steamship Company.

V V

The International Oxygen Company announces the appointment of Mr. R. M. Klein as sales manager, with headquarters at the Company's main office, 115 Broadway, New York. Mr. Klein brings to his new position a thorough technical training and a comprehensive experience as an engineer in U. S. Government employ, as salesman and sales manager for the Diehl Manufacturing ompany, and as manufacturers' representative handling a number of mechanical lines.

V V

R. A. Bull, who has been connected for the past year with the Chicago Steel Foundry Company, Chicago, has been elected vice-president and general manager of the Duquesne Steel Foundry Company, Coraopolis, Pa., and has entered upon his new duties. Mr. Bull was formerly president of the American Foundrymen's Association.

V V

C. Edwin Clarke formerly master mechanic of the Cambria Steel Company, Johnstown, Pa., is now chief engineer of the Wilmington Steel Company, Wilmington, Del.

V V

The Walter A. Zelnicker Supply Company and affiliated companies are now represented in the Birmingham district by Mr. Thomas A. Hamilton, who for the past fourteen years has been connected with Crane Company, prior to which he was superintendent of the East St. Louis Plant of the Zelnicker Car Works. Mr. Hamilton will have charge of both buying and selling in the southeastern territory.

V V

Sherley S. French, formerly general manager of the William Tod Company, Youngstown, Ohio, has now a similar position at the plant of the General Fireproofing Company, of Youngstown. Before going with the William Tod Company, Mr. French was chief clerk at the mill offices of the Brier Hill Steel Company.

V V

J. D. Holloway, Pittsburgh district sales manager for the Wheeling Steel & Iron Company, Wheeling, W. Va., has gone to Fort Benjamin Harrison Camp at Indianapolis, as a member of the Army Officers' Reserves.

V V

T. P. Draper, assistant superintendent of blast furnace

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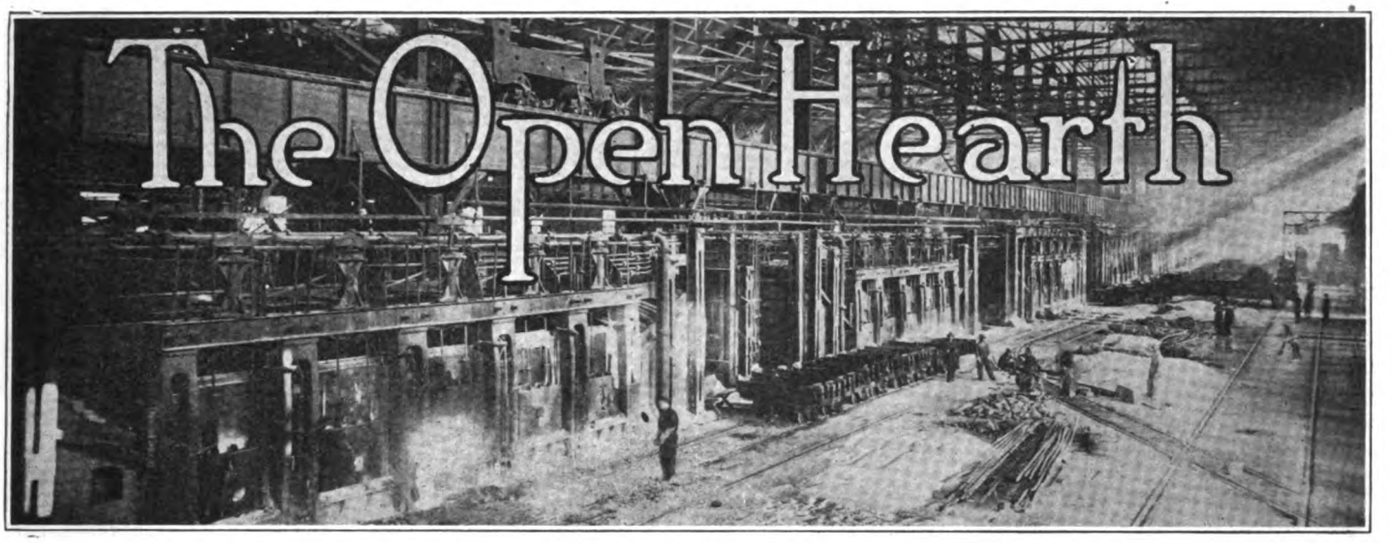

and steel department of the Youngstown Sheet & Tube Company, Youngstown, Ohio, has resigned, effective July 1, to become assistant general manager of operations of the Trumbull Steel Company. Mr. Draper has been with the Youngstown Sheet & Tube Company for nine years. F. C. Farrell has been made assistant superintendent of the converting and blooming mill departments; A. R. Finch is foreman of the converting mills to take the place vacated by Mr. Farrell. A. L. Smith has been named assistant superintendent of the open-hearth departments. H. S. Braman, superintendent of blast furnace and steel department, is assisted by C. H. Elliott.

V V

C. A. Hill who has been in the employ of the Mark Manufacturing Company, at Indiana Harbor, recently accepted a position as assistant chief draftsman with C. P. Perin and S. M. Marshall, consulting engineers, who are designing a $20,000,000 steel plant for the Tata Iron and Steel Company.

V V

Among those in the servicie of the American Steel Export Company, New York ,who have been called to the colors is K. G. Martin who was granted an honorable discharge from the 22nd Regiment, Corps of Engineers, N. G. N. Y., in order to be able to accept a commissioin as Captain, Officers Reserve Corps, Motor Transport Service. His membership in the American Society of Mechanical Engineers, American Institute of Electrical Engineers, National Electric Light Association, Society of Automobile Engineers, New York Electrical Society and American Museum of Safety, indicates his wide acquaintanceship wth engineering practice and the knowledge he will be able to bring to bear on military problems.

V V

J. Clarke Kennedy, uncle of Julian Kennedy, the iron and steel engineer, died at his home in Youngstown, O., recently, aged 80. Mr. Kennedy engaged in the iron and steel business shortly after his return from service in the Civil war. He was actively connected with the construction and operation of the old Brier Hill furnace and furnaces at Struthers, O., Lowellville, O., and in the Buffalo and Pittsburgh districts.

V V

Frank F. Thompson, for many years with the Gulf States Steel Company, at both the Ensley and Gadsden, Ala., plants, has been made assistant manager of works.

V V

Abram F. Huston, president of the Lukens Steel Company, Coatesville, Pa., has been elected vice president and director of the National Bank of Chester Valley, Coatesville, to succeed William H. Gibbons, resigned.

V V

Frank S. Ray, who for a number of years represented the Bridgeport Crucible Company, Bridgeport, Conn., throughout the east, has taken a similar position with the Naugatuck Valley Crucible Company, Shelton, Conn., recently organized.

V V

W. L. O'Connell has resigned as assistant sales manager of the De Forest Sheet & Tin Plate Company, Niles, O., to join the firm of Watson Bros., New Castle, Pa., dealers in iron and steel sheets, and has assumed his new position.

V V

William P. Palmer, president of the American Steel & Wire Company, has gone to Blue Hill, Me., for the summer. While away Mr. Palmer will make his headquarters at the north works of the company in Worcester, Mass., going to Maine for the week-ends.

V V

Edgar C. Felton, formerly president of the Pennsylvania Steel Company, has accepted an appointment as director of the department of civilian service and labor under the committee of public safety, Philadelphia. In addition to being connected with various railroads and steel companies, Mr. Felton now is on the board of managers of the Girard Trust Company, director of the Franklin National bank and the Farmers and Mechanics National Bank.

V V

Henry K. Lackland and James K. Payne, composing the firm of Lackland-Payne Refractories Company, announce the opening of their office, 1603 Boatmen's Bank Building, Broadway and Olive street, St. Louis, Mo.

Prof. F. E. Austin, E. E., has just published a book entitled "Examples in Battery Engineering." The arrangement of the subject matter, under important subject heading adapts the book for use as a text book and it can also be useful to the pactical electrician, operator of submarines and of automobiles.

The book has 90 pages and is printed by the New Era Printing Company, Lancaster, Pa., and sells at $1.25.

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Some Pointers on By-Product Coke Oven Operations

It will assist in following the few descriptive studies of coke to give a brief account of the generally accepted theory of the coke process. The development of this theory is due to several German investigators, notably Much, Hilgenstock, Rau, and Simmerbach,* and it has received such abundant confirmation from every practical standpoint that there can be no question of its soundness.

Let Fig. 1 represent a section across a by-product coke oven immediately after the charge of coal is introduced. The layer of coal next to each wall A and B is very rapidly heated. A complicated process of destructive distillation begins, and at a temperature of about 375 to 400 deg. cent. the layer becomes soft and pasty. The pasty mass is for a while in a state of violent ebullition, due to the rapid expulsion of its volatile matter, and then rapidly solidifies, the indurated residue retaining the vesicular form and structure of the pasty, foaming stage.

The adjacent layer toward the interior has in the meantime reached the pasty stage, the fusion being assisted by the penetration of some of the soft material forced over from the outer layer. The gases and vapors follow always the line of least resistance and pass through the porous outer layer and up along the wall of the oven instead of forcing their way through the viscous inner portion of the fused layer, and then through the mass of coal. In passing through the highly heated porous layer, the hydrocarbons undergo a partial secondary decomposition, depositing part of their carbon on the cellular surface just formed, thus building up and strengthening the coke. The coking process is thus to be conceived as involving the formation of a fused zone, and the gradual advance of this zone toward the center of the oven, the evolved gases and vapors depositing part of their carbon in the vesicular mass left as the zone progresses. The condition of the material in the oven when the coking has fairly well advanced may be represented by Fig. 2: c is the portion already coked, d is the fused zone merging into an adjacent zone e, which, being in a state of incipient fusion, is more vicous: f is the uncoked coal.

The actual thickness of the fused zone is probably not over ½ in. The drop of temperature across this narrow zone is very great, and the interior of the oven remains camparatively cool, even at an advanced stage in the coking process. Simmersbach's experiments on a Koppers oven of 500 mm. (19⅞ in.) mean width, operating on 29 hours' coking time with a final maximum temperature of 1120 deg. cent., showed that the temperature in the middle of the oven, 1 meter above the floor, remained about 10 deg. cent for 2.5 hours after charging; then rose to 100 deg. cent., and remained at this temperature until 13 hours after charging. At 20 hours the temperature was only 140 degrees cent.

The rate of advance of the two zones toward the center of the oven depends principally upon the temperature of the walls A and B. In present practise, with ovens 18 inches wide and wall temperatures about 1000 degrees C, the average rate is about ½-in. per hour. The initial rate, is however, much more rapid than this, and decreases as the center of the oven is approached.

As the coking progresses, cracks or joints develop perpendicular to the walls of the oven, thus determining the blocks of coke as they are eventually formed when the oven is discharged. These cracks form avenues of escape for a large percentage of the gases, hence the amount of deposited carbon is greater in proportion on the surfaces of the blocks than in the interior. Eventually the two zones merge at the center of the oven (Fig. 3), and, with the practically complete expulsion of the last of the volatile matter, the coking process is finished. There is always a distinct parting in the center of the oven, so that the length of the blocks is equivalent to about half the width of the oven. Most of the coke immediately adjacent to the walls of the oven is covered with a skin of carbonized pitch. The true form of the blocks may be seen in a few places where this has been broken away.

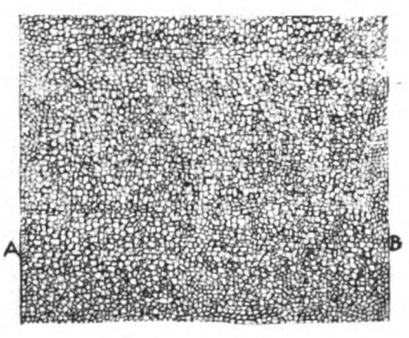

FIG. 1

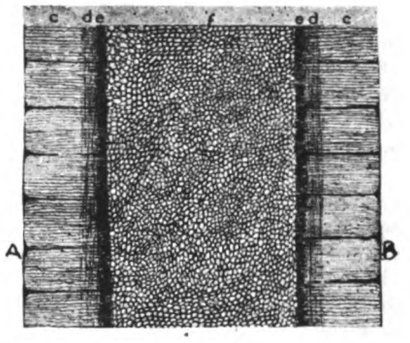

FIG. 2

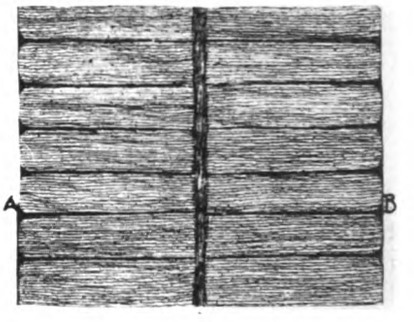

FIG. 3

The shape of the coke is characteristic, depending upon the coal used, and to an extent, upon the heat treatment. The coke-oven man classes his product as either blocky or fingery; the former being preferred. As a rule, the coke from coals of over 30 per cent volatile matter is apt to have a fingery tendency—highly pronounced if the coal has a high oxygen content. By coking very slowly at temperatures lower than ordinary, the fingery tendency may be disguised or entirely eliminated. By disguising it, we mean the product will appear to form large, massive blocks, which, if closely examined, will be found to be bundles of slender pieces more or less firmly cemented together. If the heat treatment be very carefully regulated during the coking process—genuine, firm, blocky coke may be made from coals regarded as producing the fingery variety.

* Grundlagen der Kokschemie, Berlin, Julius Springer, 1914. Abstract of a paper presented at a joint meeting of the Franklin Institute and the Philadelphia section of the A. S. M. E., by C. J. Ramsburg and F. W. Speer, Jr.

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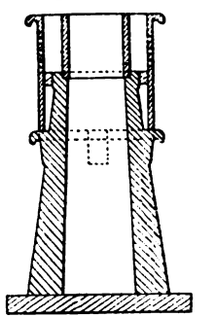
RECENT PATENTS

Ingot Mold.

Patent No. 1,229,295 has been granted to Andrew Laitsch for a new ingot mold tapering toward the top and thinner at the upper end than at the lower end, having lugs near the upper end, in combination with an auxiliary casting, constituting a combustion chamber surrounding the upper end of the mold. In combination with an extension to the mold formed of refractory material, the space between the extension and the walls of the auxiliary casting, a chamber is formed for the reception of fuel, for the purpose of maintaining a high temperature at the upper end of the mold, whereby piping is prevented.

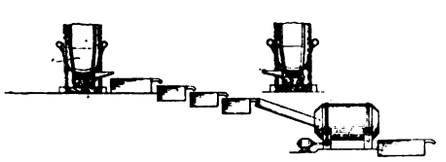


Low-Carbon Mangenese Alloys.

Ernest Humbert, Niagara Falls, N. Y., has been granted patent No. 1,228,925 for a method of treating commercial ferromanganese containing about 6 per cent carbon which consists in adding manganese oxide thereto and electrically heating the mass to a suitable temperature well above 1700 degrees centigrade to cause the oxidation of the carbon until it is reduced to about one per cent or less.

Process of Treating Slags.

James Brown Herreshoff, Jrr., New York, has been granted patent No. 1,231,349, for a process of recovering from metallurgical slags a contained metallic ingredient, which comprises mechanically washing the molten slag with a series



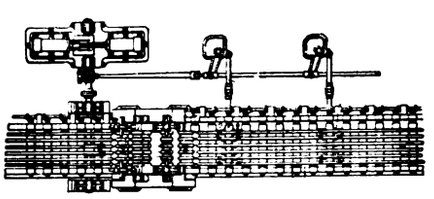
of baths of molten material, containing a smaller percentage of such ingredient than the said molten mass, and each bath of the series containing a smaller percentage of such ingredient than the bath immediately preceding in the series.

Preparation of Tin Plate.

Friedrich Mueller, Vienna, Austria, assigner of one-half to Frederick Mueller, Chicago, Ill., has been granted patent No. 1,231,285, for a process of tinning black plate on one side only, which consists in coating one side of the previously annealed and pickled black plate with fat, in dipping the thus prepared black plate in an acidulated solution of a copper salt which precipitates a dense deposit of copper upon the free surface of the black plate, in changing this aforesaid deposit of copper into sulfid of copper, previous to passing the plate through the tinning pot and tinning the plates afterward.

Rolling Mill.

Joseph E. Fawell, Pittsburgh, Pa., assignor to McKintosh-Hemphill and Company, has been granted patent No. 1,233,209, for a rolling mill. The mill has means for turning the metal lying on the table and for simultaneously shifting the rolls. A pair of rolls are moved in the arc of a circle. The roll moving mechanism also moves the metal across table.



The patent also includes a device for rotating a housing containing two pairs of nonreversible rolls, and means operative, by the housing turning means, for moving an article laterally across the front of the rolls.

Blast Furnace Process.

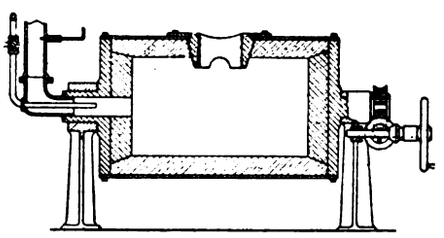
Patent No. 1,231,260 has been granted to Joseph E. Johnson, Jr., for process of producing ferro-silicon of substantially 50 per cent silicon in a blast furnace, which consists in charging the furnace with ore and fuel, and supplying a blast containing equal or substantially equal parts by weight of oxygen and nitrogen to reduce the silica on a scale to produce a ferrro-silicon containing a high percentage of silica.

Metallurgical Process.

Joseph E. Johnson, Jr., New York, N. Y., has been granted patent No. 1,231,250 for a process of converting steel-scrap into cast iron, which consists in melting the steel-scrap to produce a molten bath, and then introducing into the bath a sufficient quantity of carbid of silicon to convert the steel into cast iron.

Metal Melting Furnace.

Patent No. 1,229,494, has been granted to Dwight S. Marfield, Cincinnati, Ohio, assignor to The Buckeye Products Company, for a metal melting furnace. The melting chamber is rotatably mounted upon substantially horizontal bearings. An inlet port for fuel and air through one



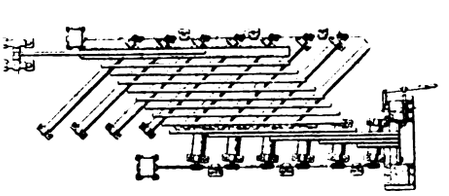
of the bearings, a charging and pouring port leading through the wall of the chamber at substantially right angles to the axis of rotation are included. The charging port has an annulus at its inner end projecting into the chamber and adapted to baffle the combustible gases as they sweep along the wall.

Fusing Ores.

Raoul Pierre Pictet, of Paris, France, has been granted patent No. 1,230,431, on art of fusing ores, in which the following is claimed: The process of smelting ores to obtain the uncarbonized metal or metal having a given degree of carbonization, which consists in stacking a furnace with layers of ore of a previously ascertained composition, alternating with layers of carbon.

Feeding Mechanism.

Victor E. Edwards, assignor to the Morgan Construction Company has been granted patent number 1,228,543, for a feeding mechanism for metal cutting



shears. The conveyer rolls, which transmit the bars to the shear have their axes skewed with respect to the axis of the bars, the rolls of one series being skewed at a different angle from the rolls of another series. A combined endwise and sidewise movement is imparted to each bar.

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WITH THE EQUIPMENT MANUFACTURERS

AN OPTICAL PYROMETER FOR WORKS USE.

For the measurement of temperatures above, say 1,400 deg. F., only two methods have been found practical for works service. One of these is based on the thermocouple, used either with the millivoltmeter or with the more accurate and reliable potentiometer. The other method is based on the laws of radiation and includes both the radiation pyrometer, which would be more properly named the "total radiation" pyrometer, and the optical pyrometer, which utilizes only that radiant energy visible to the human eye.

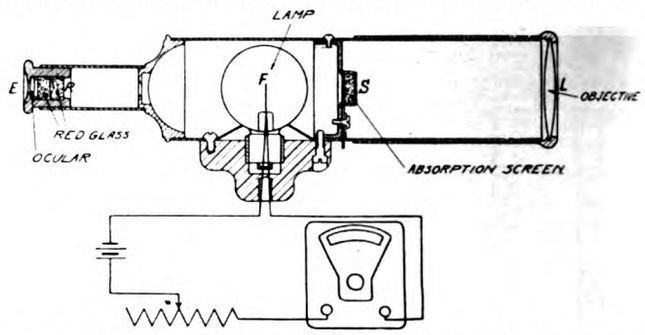
The greatest success has been attained by separating out one kind or wave length of radiation, usually that which excites the sensation of red, and comparing the intensity of this one-color light with the intensity of the light of the same color emitted by a standard source of light. The eye is very sensitive when comparing the brightness of two surfaces when one is superposed upon the other, and after having arranged to have light from the hot body and light from the

The Leeds & Northrup optical pyrometer in use.

standard of comparison viewed in this relation, they can be made equal, either by varying the amount of light received from the incandescent object, or by varying the intensity of the standard of comparison.

The latter method, that is, variation of the intensity of the standard of comparison, is preferred and used by the United States Bureau of Standards, also by the Reichsanstalt, of Berlin, where its practical application has been brought to a high degree of perfection by Messrs. Holborn and Kurlbaum. The Leeds & Northup Company, of Philadelphia, working under the fundamental Morse patents, has lately carried on a prolonged investigation and development of this type of optical pyrometer with a view of realizing a high degree of accuracy and reliability in a simple and portable device. The instrument, which is illustrated herewith, is suitable for measuring from dull red (about 1,100 deg. F.) up to the highest known temperature.

The instrument can be calibrated by sighting it upon bodies whose temperatures are known, either by means of a thermocouple pyrometer, or by the melting or freezing of various substances. The constancy or reliability depends upon the constancy of the lamp, that is, its ability always to shine with the same intensity when receiving the same current. This matter has been investigated exhaustively by the United States Bureau of Standards and by the Nela Park Laboratory of the National Electric Light Association, also in the laboratory of the Leeds & Northrup Company, and it has been found that after a tungsten filament is thoroughly aged, that is, burned for some time at a temperature higher than that to which it will be subjected in service, no sensible



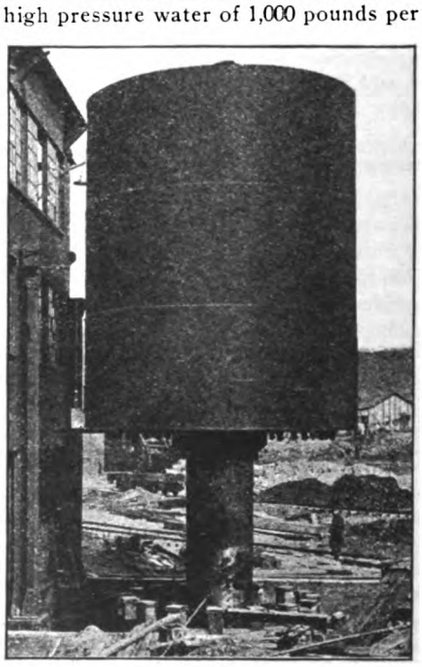
Opitcal system and electrical circuit of the Leeds & Northrup optical pyrometer.

variation thereafter occurs. The instrument is so designed that one lamp can quickly be replaced by another, and by keeping two lamps, their correctness can always be insured by checking one against the other.

The instrument itself is handy and portable, weighing only about a few ounces, and can be sighted as easily as an opera glass. The case, containing the battery, rheostat and milliammeter, is designed to be slung about the neck, and weighs about 10 pounds.

A LARGE ACCUMULATOR.

The illustration shows a large hydraulic accumulator, built by the Southwark Foundry & Machine Company, Philadelphia. This accumulator has a capacity of 3,000 gallons of high pressure water of 1,000 pounds per sqnuare inch pressurt.



3,000-gallon accumulator.

The accumulator ram is 5 ft. diameter and 28 ft. long, and weighs 120,000 pounds. The cylinder, which is of open hearth steel casting, weighs 140,000 lbs. The base plate is 18 ft. in diameter and weighs 85,000 pounds.

The tank is supported by 24 tie rods. The tank itself is 20 ft. in diameter and 24 ft. high.

The pressure water enters the accumulator in the center of the bottom being forced through a pipe extending upward into the cylinder, while the water is discharged through a side outlet.

This accumulator complete, not including the ballast, weighs 450,000 pounds, requiring 1,400 tons of ballast to give 1,000 pounds pressure.

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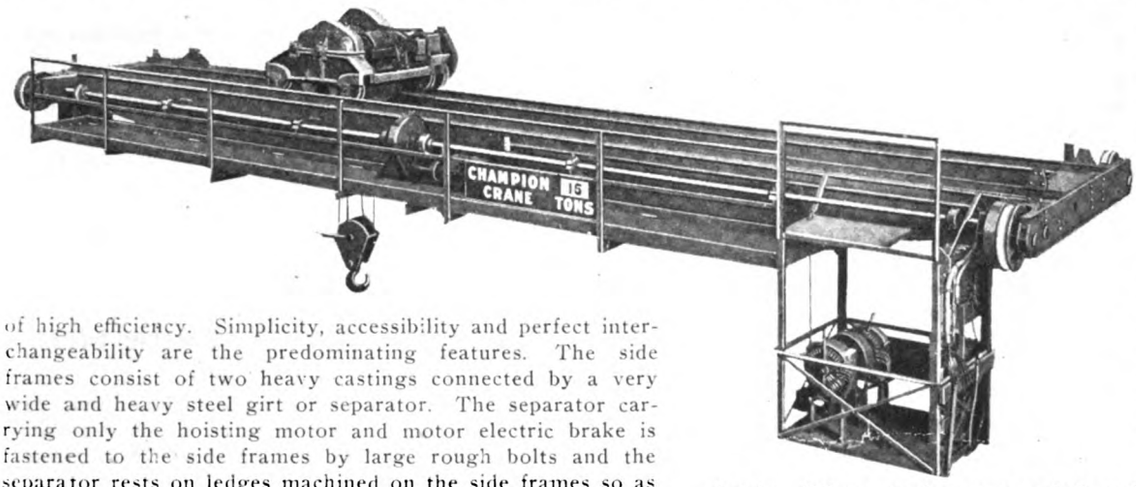
STEEL MILL TRAVELING CRANE.

The Champion Crane Company, of Cleveland, Ohio, has recently made some improvements in their crane, with a view of meeting even the most severe requirements which are usually called for by steel mill crane specifications and at the same time producing a machine from the standpoint



of high efficiency. Simplicity, accessibility and perfect interchangeability are the predominating features. The side frames consist of two heavy castings connected by a very wide and heavy steel girt or separator. The separator carrying only the hoisting motor and motor electric brake is fastened to the side frames by large rough bolts and the separator rests on ledges machined on the side frames so as to relieve the bolts of all shearing strains.

The trolley is designed with a view of receiving any standard crane hoist motor and motor brake, both AC or DC. Each hoist motor is provided with a magnetically operated brake of the single solenoid type with a gripping band, which is released by the current which operates the motor and is applied when the current is interrupted. The band is adjustable for wear without throwing the magnet plunger out of adjustment.

The hoist mechanism is provided with an antomatic switch, limiting the upper travel of the hook to prevent damage due to the overhoisting or "double blocking." The device or limit contact is actuated by the hook block itself in arriving at the predetermined limit. The magnetic switch is normally closed and held in a closed position at the switch board on the operator's cage, and is opened whenever the circuit is so interrupted. In other words the safety hoist limit operates by "breaking" and not by "making" a circuit, which latter method cannot be done with certainty. The trolley is also designed to receive any other approved form of limit contact in the market.

The trolley is so designed that ready attachment can be made of all standardized safety devices, such as truck wheel guards, bumpers, safety-pans and also for the ready attachment of side platforms to the sides or ends of trolleys for the purpose of securing more perfect accessibility.

AUTOMATIC STARTERS FOR INDUCTION MOTORS.

Motor Starter.

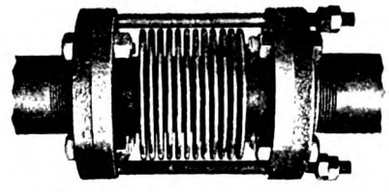
The Westinghouse Electric & Manufacturing Company have recently placed on the market some new types of automatic starters and controllers for motor-driven machinery. One of the starters is shown in the accompanying illustration. These automatic starters are for use with single phase or polyphase squirrel cage and wound-rotor induction motors, where it is desired to start the motor from a remote point or where automatic acceleration is required to guard against improper starting by unskilled, operators. They are simple, reliable, and rugged in construction, consisting of a magnetic contactor panel and a master switch, which may be either a push button, a float switch, a pressure regulator, or similar device for closing the control circuit, depending upon the service. The vital element is the magnetic contactor. The contactors used on these starters are of a type which has been used by the Westinghouse Company with marked success in the steel mill. The contactors are opened by strong spring action assisted by gravity. The destructive action of the arc is reduced to a minimum by strong blowout coils and arcing horns.

The operation of the starters is very simple. When starting motors it is only necessary to press a button, close a small knife or snap switch. The starter then automatically makes the proper connections to limit the starting current to a suitable value and to vary the time required for acceleration according to the load on the motor, thus preventing damage to the machinery by too slow or too rapid acceleration, and saving time by bringing the motor to full speed at the most rapid permissbile rate. When used for pump or compressor service in connection with a float switch or pressure gauge, the action of the starters is entirely automatic, the motors being started when the pressure or liquid level of the tank controlled falls to a predetermined point and stopped when the desired maximum pressure or level is reached, or vice versa.

When an automatic starter is used in connection with a wound-rotor motor, the line switch is first closed, with the maximum resistance in the rotor circuit. When the speed falls to predetermined value, a relay closes a magnetic contactor which cuts out a part of the resistance in the rotor circuit. Each contactor operates in a similar manner, cutting out its portion of the resistance at the proper time until all the resistance is short circuited by the last contactor.

EXPANSION JOINT.

An interesting type of expansion joint is manufactured by the R. D. Nuttall Company, Pittsburgh. The joint is made in one piece, machined inside and out, from a solid, hammer-forged, blank, which is oil tempered. The corrugations are machined from the solid blank—not molded or bent to shape. These corrugations allow expansion or contraction by the same action as an accordion or bellows. The thin steel walls require careful machining. Nuttall one-piece joints are made in all sizes with standard flanges for either high or low pressure. The high pressure joints are designed to allow an expansion of 1 in. and a contraction of pressure allows 5/16 in. over or under normal or a total movement of 5/8 in. Limiting bolts are provided as shown to prevent expansion beyond the safe limit and a sliding sleeve is also inserted in the high pressure joints to minimize friction and help support the internal pressure strain.



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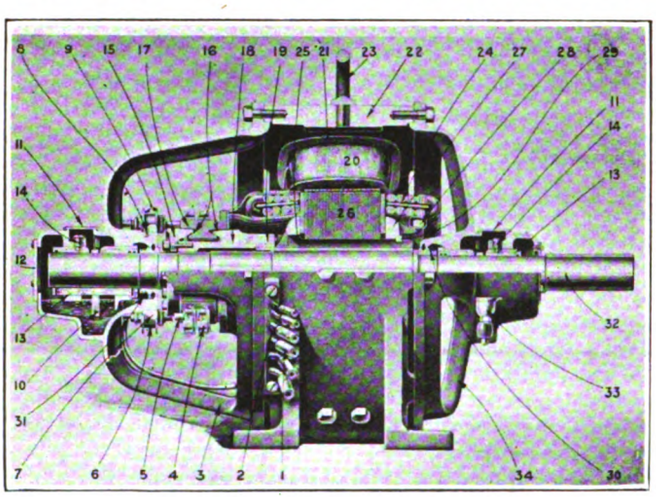
HEAVY DUTY ELECTRIC MOTORS.

The Relience Electric and Engineering Company, of Cleveland, Ohio are manufacturing, a special type T, heavy duty motor, which is particularly suited for the rugged steel mill service One type is fully enclosed so as to be dust proof. The feet are cast integral with the frame. Wide ribs are carried up from the feet in such a way as to give the most effective support. The motor frame has four laminated main poles which are securely fastened to the frame by cap-screws. The flat section at the pole tip provides a surface against which the coil can press snugly without danger of wear. The field coils are insulated and provided with protective features to meet hard service conditions. Double cotton covered wire is used for the commutating coils, which are wound in a form dipped in insulating varnish and baked. They are assembled in press board and fiber spools of the same kind that are used for the main field coils.

The bearings are cast-iron shells babbitted with metal containing over 70 per cent tin and only a trace of lead. Babbitt liners are locked in place by depressions in the cast-iron shells. In addition to the "oil throws" on the armature shaft, other precautions are taken to keep the oil in its proper place. Spiral oil-grooves insure proper distribution of the oil, and the bearing is shouldered in the end brooket



Cross sectional view type T motor.

and held aganst rotation by a large dowel screw under the oil-hole cover. When desired split bearings may be supplied at the pinion end to provide for taking out the armature without removing the pinion. All armature cores are built up of electrical steel punchings insulated with core plate varnish. These punchings are mounted on a cast-iron spider and securely keyed to it.

The accompanying illustration shows the parts of the motor in detail, the figures below referring to the cut:—1.—Leads and connectors. 2.—Terminal board. 3.—Front bearing bracket. 4—Brush holder. 5—Brush holder stud. 6—Brush stud insulation. 7.—Brush yoke. 8.—Brush yoke dowel. 9.—Bakelite insulating washers. 10.—Oil ring. 11.—Oil hole cover. 12.—Bearing end cover. 13.—Bearing. 14.—Bearing Dowel. 15.—Commutator metal V ring. 16.—Commutator insulating rings. 17.—Commutator segments. 18.—Commutator sleeve. 19—Commutator key. 20—Field coil. 21.—Field coil insulating washer. 22.—Frame. 23.—Eye bolt. 24.—Armature coils. 25.—Armature spider. 26.—Armature core. 27.—Armature end plate. 28.—Armature coil suppporting ring, (part of No. 27). 29.—Armature end plate key. 30.—Oil throw. 31.—Oil throw. 32.—Armature shaft. 33.—Oil overflow. 32.—Back bearing bracket. 35.—Main field pole. 36.—Commutating pole. 37.—Commutating coil. 38.—Field coil support. 39.—Armature.

NEW TRADE CATALOGUES.

The Whiting Foundry and Equipment Company, of Harvey. Ill., has issued a new catalogue entitled "Electric Travelers" which describes and illustrates many different kinds of electric cranes and their industrial application. The firm located near Chicago has increased the floor space of the crane department of about thirty-five per cent.

Catalogue number ten, describing the Smith Type "MB" gas producer plants has been issued by the Smith Gas Engineering Company, of Lexington, Ohio. The book is well illustrated and contains interesting operating data.

An interesting pamphlet has been issued by the Hyat Roller Bearing Company describing the application of this bearing in the steel industry.

Production of Low Carbon Electric Steel.

(Continued from Page 371.)

case. No special formula can be adhered to in forming the second slag. The slag must be made up to suit the conditions in the furnace, but the following formula has given good results as a base to form the reducing slag:

Lime—40 pounds per ton of steel.
Sand—3 pounds per ton of steel.
Spar—6 pounds per ton of steel.
Coke dust—3 pounds per ton of steel.

From practice it has been found very satisfactory to melt down low and recarburize instead of melting down to the desired carbon. If the carbon rises when you have on carbide slag and you are a little low, you are on the safe side, but should you melt down to the desired carbon and the heat take up some of the carbon from the coke used in forming the carbide slag, you may have to ore down. This means that you will have to form new slags which results in loss of time and labor. The following analyses have been found to be pood practice in the steel castings of the above two cases:

No Special Analysis.

Carbon	.20 to .25
Sulphur	Not over .05
Phosphorus	Not over .05
Manganese	.50 to .60
Silicon	.25 to .35

Special Analysis.

Carbon	.20 to .25
Sulphur	Under .03
Phosphorus	Under .03
Manganese	.50 to .60
Silicon	.25 to .30

Special care should be taken in the selection of scrap as to phosphorus and sulphur if the process of refining is not wished to be carried out.

The first or oxidizing slag is always an ink black slag. The second or reducing slag may appear in one of three forms; a yellowish brown or managnese slag, a somewhat glassy white or silicon slag, or a pure carbide slag. An ideal slag is the pure carbide slag. It can be recognized by its tendency to pulverize after cooling on being exposed to the air. It also gives off a carbide gas when moistened with water. Low carbon heats have a great tendency to be wild. Heats have been known to have been placed under a perfect carbide slag and still be wild. A wild heat can usually be killed by the furnace addition of ferro silicon and sometimes a little ferro manganese. The use of titanium as a lable addition has been found to be good practice, but great care must be taken in making this introduction so that the desired cleaning takes place in the metal instead of in the slag. Six-ton heats can be turned out on the average of six heats to 24 hours with an average power consumption of about 550 kw. per ton of steel.

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